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Oysters
From the Reef to the Teeth

Mississippi
Department of Marine Resources

Oysters – From the Reef to the Teeth

COSEE
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Scott Gordon, Director
Shellfish Bureau
Office of Marine Fisheries
Mississippi Department of Marine Resources
1141 Bayview Avenue, Suite 101
Biloxi, MS 39530
(228) 374-5022 (Ext. 5026)
Cellphone: (228) 216-4009
Fax: (228) 374-5220
Email: scott.gordon@dmr.state.ms.us

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Oysters
From the Reef to the Teeth

- **History**
- **Biology**
- **Predators/Diseases**
- **Water Quality**
- **Habitat Creation**
- **Resource Assessment**
- **Management**
- **Harvest**
- **Technologies**
- **Weather**
- ***Vibrio***
- **Recipes**
- **Future**

This is a tremendous amount of information to cover, and is meant to be an overview of these main topics and how they pertain to oysters. (The perspective is from an oyster managers point of view.)

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History

History

Oystering in Mississippi dates from more than 10 thousand years ago when Paleo Indians first gathered oysters by hand in shallow coastal waters. These early inhabitants built shell mounds (middens) comprised primarily of oyster shells. These shell middens still exist and provide evidence that oysters where an important staple of their diet.

The arrival of the French to the Mississippi coast in 1699 found the Biloxi, Pascagoula, Capinan and Acolapissa tribes living there. Oysters were an important part of their diet as well.

As European settlers established colonies on the coast, they harvested, sold, traded and ate the abundant seafood present there, including oysters. Some of these settlers constructed their houses from a mixture of clay, Spanish moss, and oyster shell applied to heavy timber.

Beginning in the late 1800's, the seafood industry prospered due to the railroad, canneries, and the invention of "artificial ice", making it possible to ship seafood to other parts of the country demanding it. Biloxi came to be known as the "Oyster Capitol of the World". Oysters were "tonged" from small skiffs, and later "dredged" from "Biloxi Schooners".

Today, oysters remain important to the Mississippi Gulf Coast. Mississippi's oysters are shipped all over the country and still tonged and dredged from boats, but now with the aid of motors.

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Ancient Indian Shell Midden, Grand Bay National Estuarine Research Reserve

The earliest inhabitants gathered oysters by hand along the shoreline. They piled the empty shells into these mounds which are called shell middens. State and federal laws now protect them.

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Postcard from early 1900's showing oyster tongers in Biloxi, Mississippi.

Postcard from early 1900's showing oyster tongers in Biloxi, Mississippi.

Tonging for oysters has changed very little over the years.

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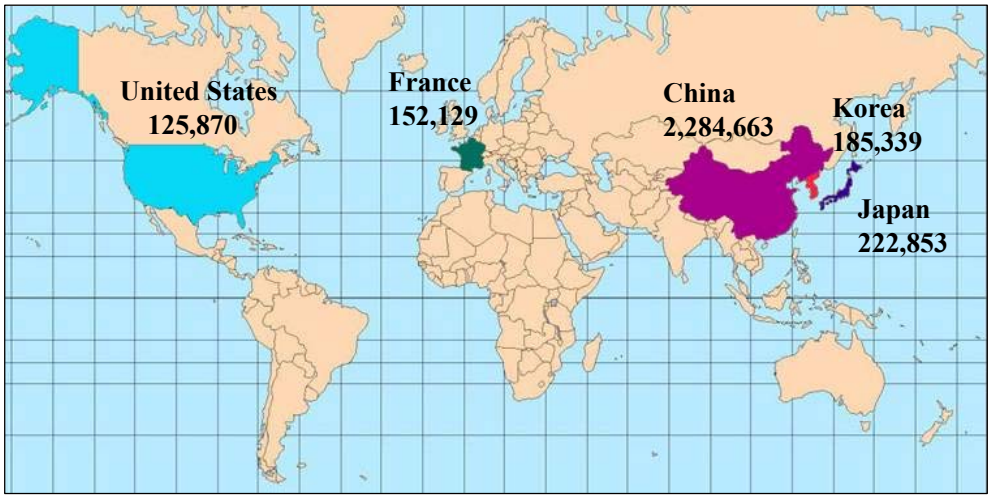
World Yield of Oysters

about 3,944,000 mt in 2000



3,944,000 metric tons equals approximately 8.695 billion pounds!
The U.S. contribution was 277.5 million pounds.
These are live weights (in the shell).

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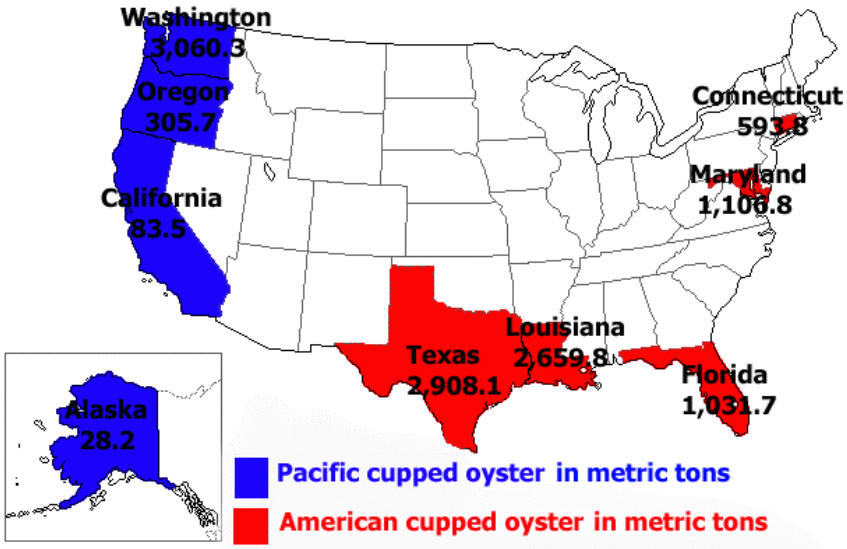
1999 U.S. Oyster Yields

Wild and farmed harvest of oyster meat was 12,587 mt.

Harvest of eastern oyster meat was 9,109 mt or 72% of the total harvest.
Harvest of pacific oyster meat was 3,478 mt or 28% of the total harvest.

Meat is 10% of the whole oyster weight



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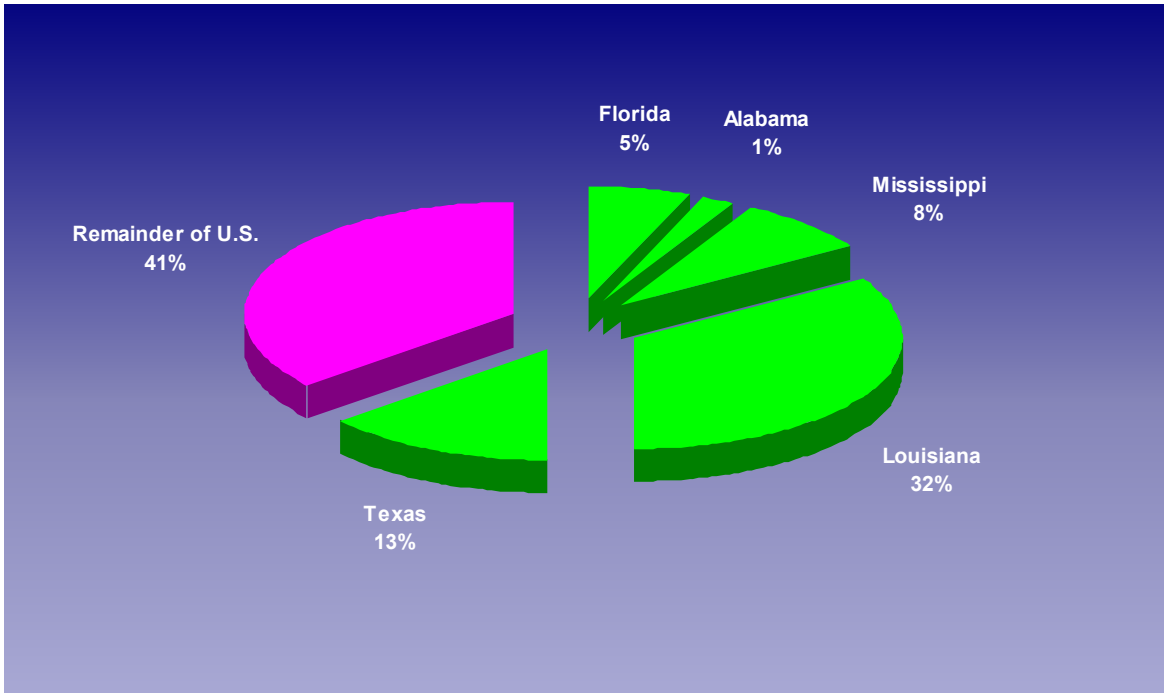
AVERAGE ANNUAL PERCENT CONTRIBUTION BY GULF STATES TO U.S. OYSTER LANDINGS (1997 - 2001)

(All species combined, pounds of meat)



Source: NMFS

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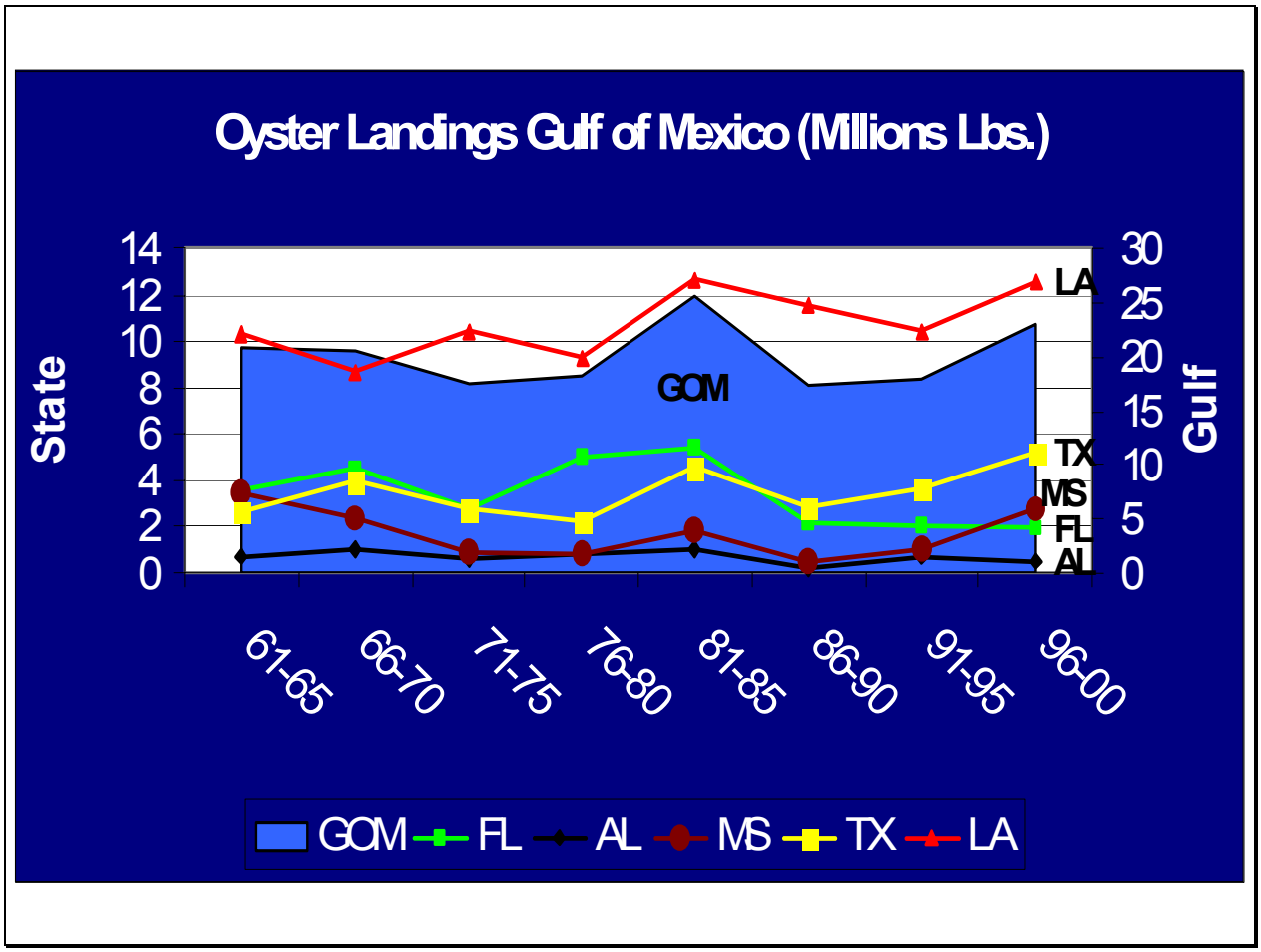
Oyster Landings Gulf of Mexico (Millions Lbs.)
State
Gulf
14
12
10
8
6
4
2
0
30
25
20
15
10
5
0
GOM
LA
TX
MS
FL
AL
61-65
66-70
71-75
76-80
81-85
86-90
91-95
96-00
GOM
FL
AL
MS
TX
LA

Slide 10


•Commercial harvest records in Mississippi date back to 1880.
•Mississippi reefs produced in excess of 380,000 sacks of oysters during the 2001-2002 Season.
•The dockside value over the last five years is in excess of 22.5 million US dollars.

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Resource
CONSERVATIONIST
• Mississippi has 10 to 12 thousand acres of productive oyster reef habitat.
• Recent annual production has exceeded 350,000 sacks.

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Industry
• Mississippi currently has 56 licensed wholesale seafood dealers of which 37 are licensed oyster processors.

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Biology

Biology
The Eastern or American oyster (*Crassostrea virginica*) is a bivalve molluscan shellfish. Bivalve molluscan shellfish are a class of invertebrate animals containing over 7000 species. The key unifying characteristics are a hinged shell with two valves and a sedentary lifestyle.
This photograph shows numerous young attached oysters or "spat" (0 - 25mm in length) attached to the clean inner surface of an oyster shell. Under the right environmental conditions, these spat could grow to 75mm (3") in about 18 - 24 months in the waters of the northern Gulf of Mexico. However, predators consume many of the young oysters while they are still in the veliger or "free-swimming" stage. Many others die on the bottom if they are unable to locate suitable cultch material on which to attach and grow.

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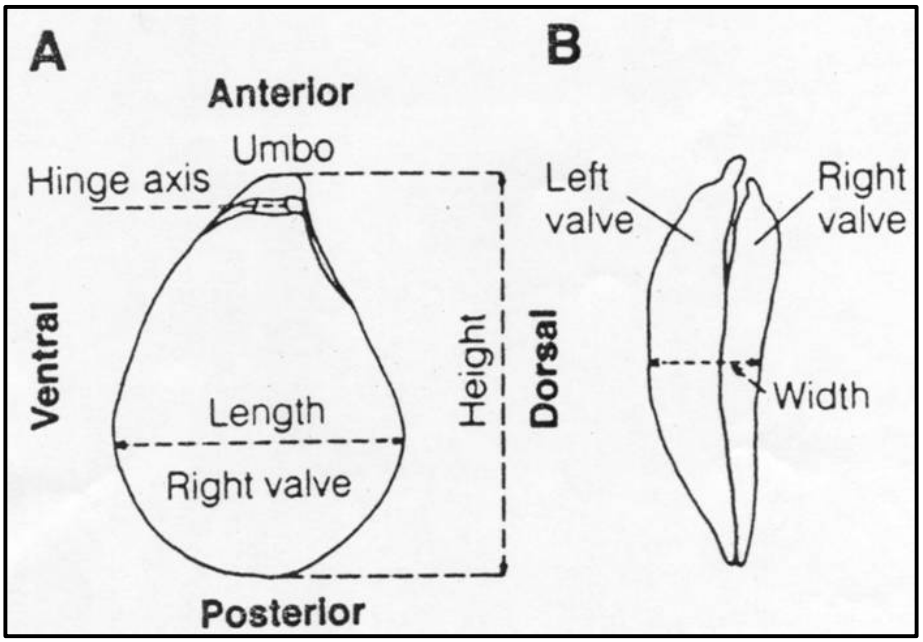
External Shellfish Orientation



Bivalve means two valves or "halves of the shell." When measuring the oyster's growth, measure the height from umbo to the lip (posterior).
Figure "A" is a view of the right valve inside of the oyster with the left valve removed.

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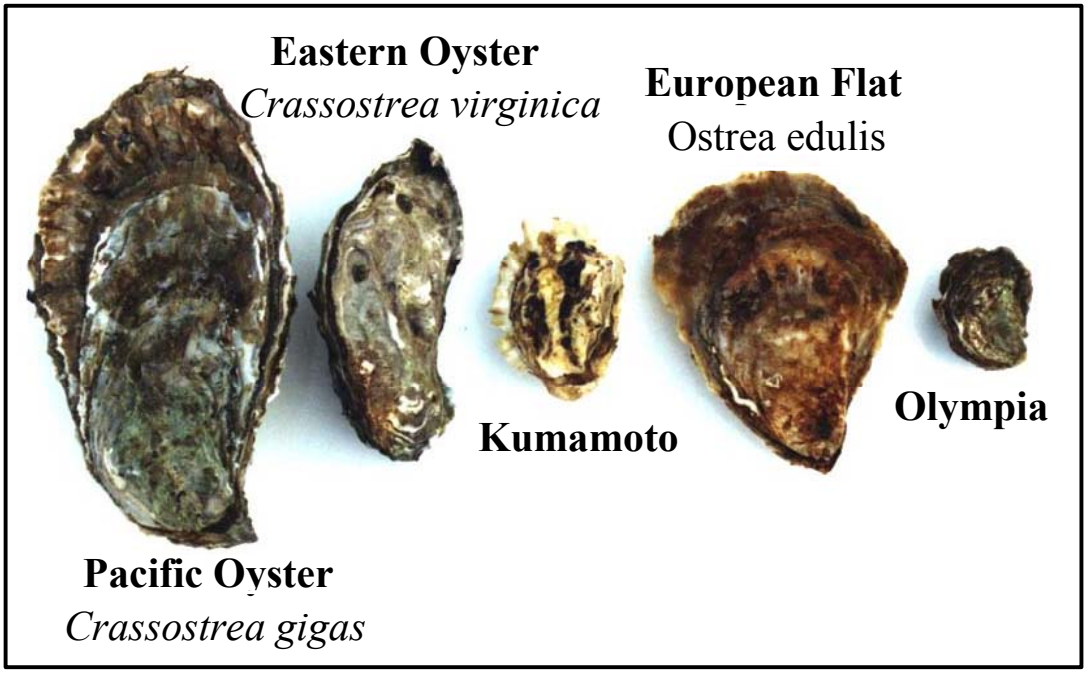
Common Oyster Species



The pacific oyster and Kumamoto's are endemic to Japan and are now widely cultured in Australia and the west coast of North America. The eastern oyster is found along the east coast of North America and Gulf of Mexico. The European flat oyster originates from France and the Olympia is endemic to the west coast of North America, but is no longer the dominate cultured species.

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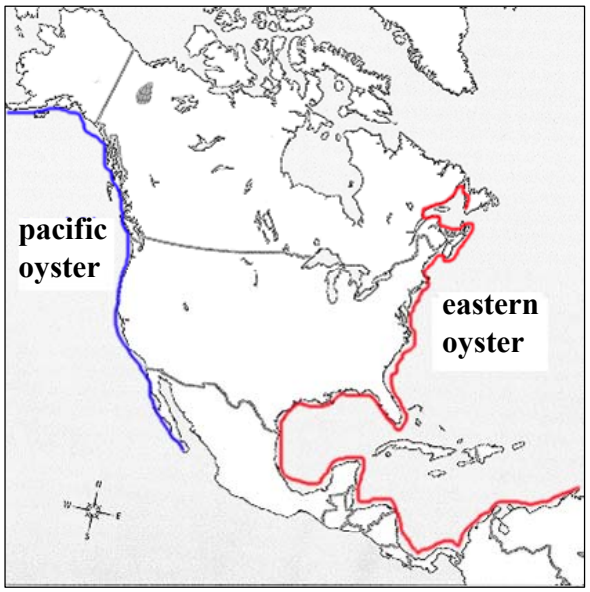
Distribution

The eastern oyster, *Crassostrea virginica,* is native to the East coast of Canada and United States, Gulf of Mexico and Caribbean, and as far south as the Northern coast of South America.

The pacific oyster, *Crassostrea gigas*, was introduced from Japan and extends from Alaska to Baja California



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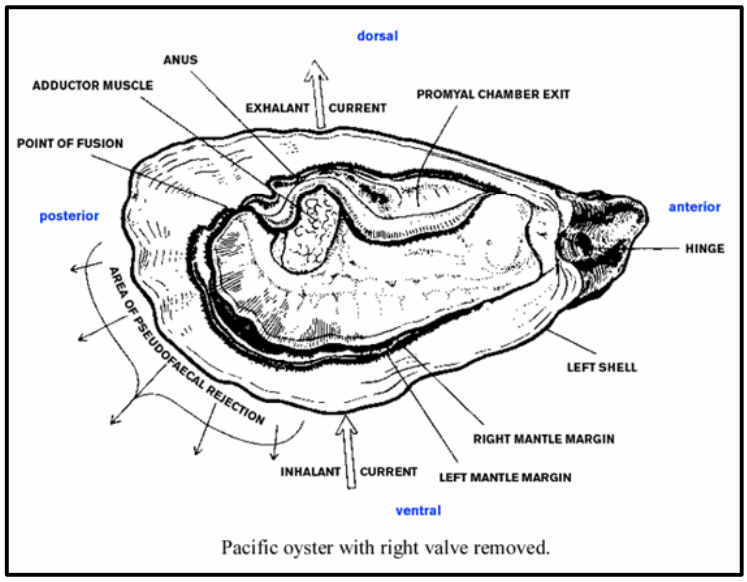
Oyster Anatomy - Adult



Pacific oyster with right valve removed.

- Shell
- Adductor muscle
- Gills
- Labial Palps
- Mouth
- Digestive Tract
- Anus
- Gonad

Particles in water travel first through the gills, then are sorted at the labial palps. Pseodofeces are ejected if the particles are too large or too small to continue through the digestive system. Next, the particles go through the mouth, then the esophagus to the stomach. What remains, passes through the intestines, digestive gland, and out the anus.

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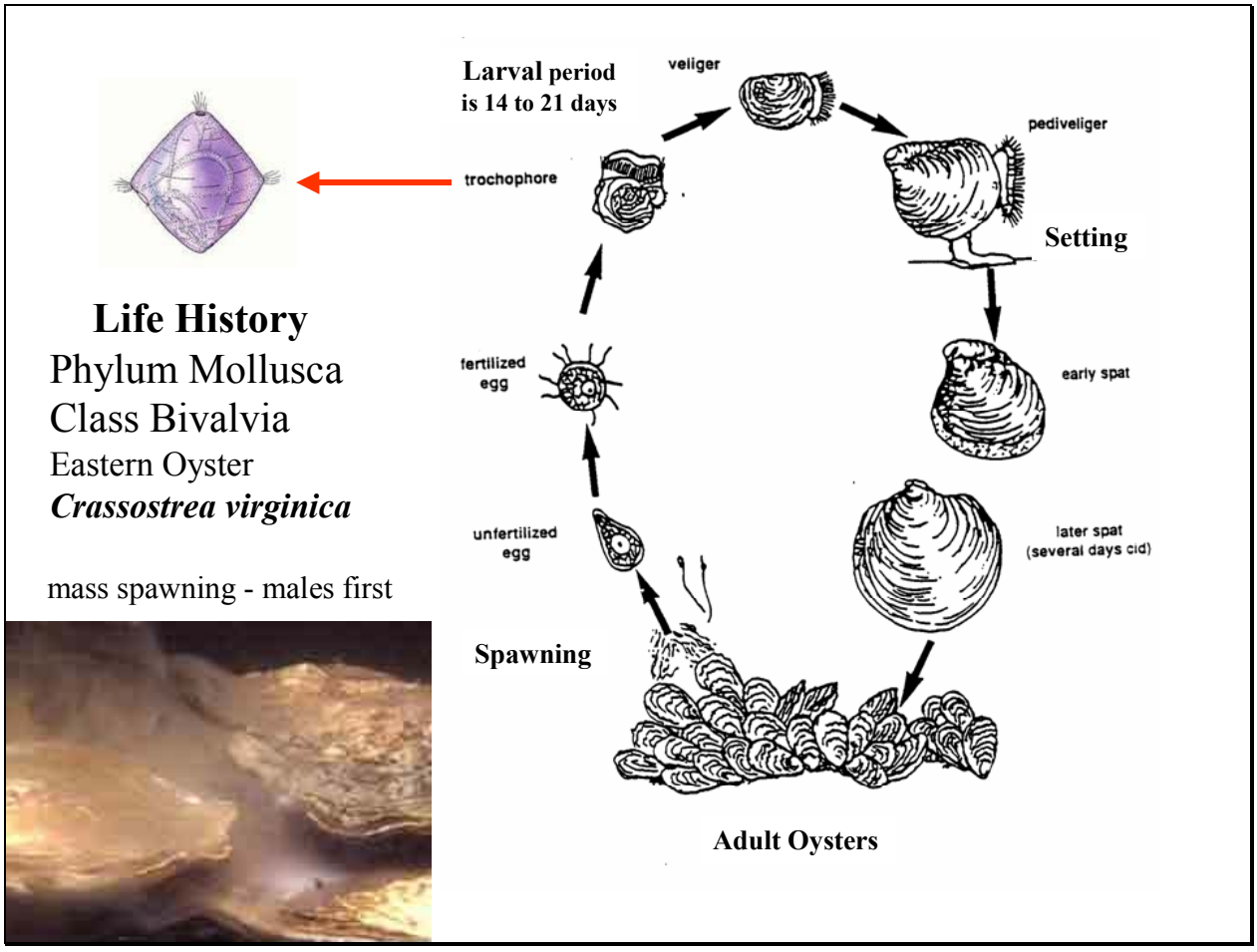

Sperm and eggs are released and fertilization occurs in the water column. Fertilized eggs develop rapidly into a microscopic swimming trochophore. After 24 to 48 hrs., the non-feeding trochophore develops into the feeding veliger stage. At this stage the larvae have a thin shell and feed primarily on tiny algae. After 14 to 21 days, larvae develop a foot and eye spots and are referred to as "eyed larvae." Pediveligers settle to the bottom and are capable of crawling short distances to find a suitable site to set. Setting occurs when the larvae cement themselves to a hard substrate (usually oyster shells) and metamorphose into a tiny oyster called a spat.
Reach sexual maturity at 1 year of age.
Protandric - Young oysters are usually male and change to female after first spawning season.
Water temperatures above 25°C trigger spawning in the Gulf of Mexico.
Salinity above 10 ppt.
Spawn between March and November

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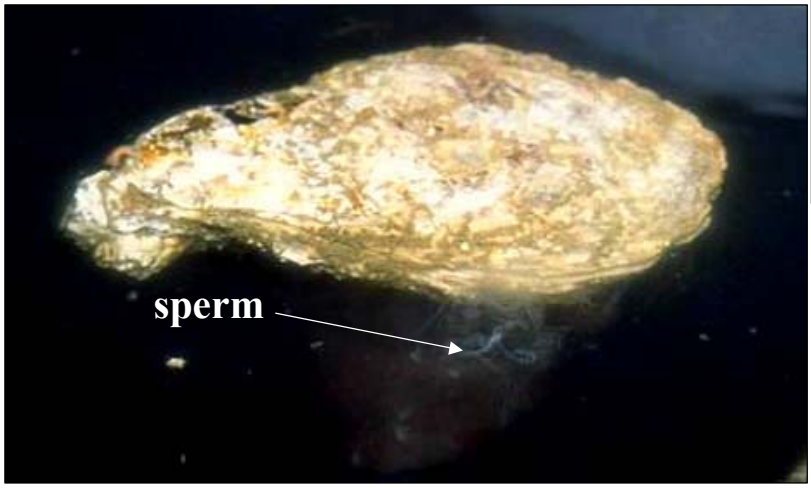
Reproduction

Sperm triggers females to release eggs. Females can release millions of eggs.



Larvae with a muscular foot looking for a site to set.

Reproduction

Oysters are a protandric hermaphroditic species. The general populous is usually male when they are young (1-2 yrs.) and become females as they are older. Females require more energy for egg production. They have the ability to change sex.

Spawning occurs when water temperatures rise in the spring. Northern oysters spawn at temperatures between 60 and 68°F (15.5 - 20ºC) while southern oysters spawn at temperatures above 68ºF (20°C). Spawning can occur throughout the warm months.

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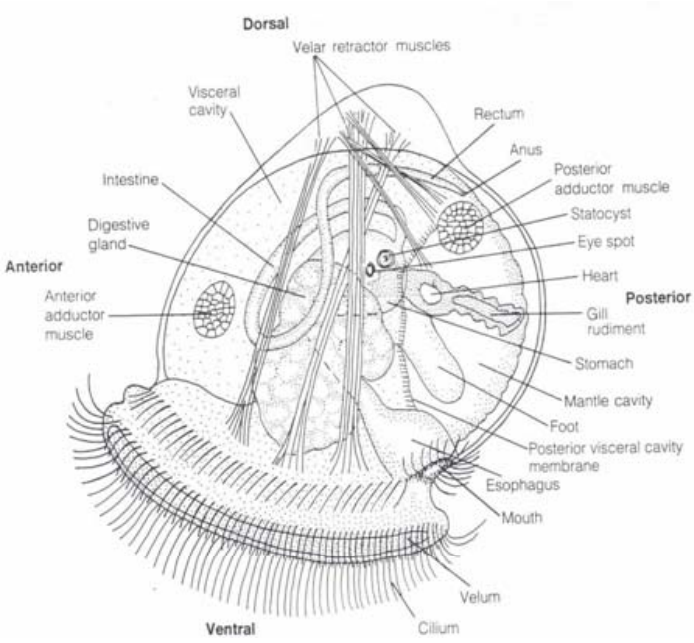
Oyster Anatomy - Larval Form

- Different Anatomy
  - velum
  - 2 adductor muscles
  - eye spot
  - digestive system



The main differences between the adult oyster and the larval oyster is the larval form has 2 adductor muscles and an eye spot whereas the adult has only one adductor muscle and no eye spot.

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Oyster Biology

• **Feeding Habits** – feed on anything 3-12 microns in size by filtering from the water and receive nutritional value from phytoplankton and detritus

• **Water temperature** – 70^{o} to 79^{o} C for best growth

• **Salinity** – 10 to 22 ppt for best growth

• **Growth to 3”** – Typically 18 to 24 months in the Gulf of Mexico

Although there is some suggestion that the optimum temperature is lower and the optimum salinity is higher for *C. gigas* than for *C. virginica,* the tolerances of the two species overlap; there is little reason to suggest that they would be limited to different habitats

Factors Affecting Oyster Growth & Survival
Salinity -- 0-35 parts per thousand (ppt)
Poor: Less than 5 ppt
Good: 5-10 ppt
Best: 10-15 ppt
Greater than 15 ppt = GOOD/BAD (Increased disease and predator mortalities)
Oxygen -- 0-10 ppm
Greater than 3 ppm
Temperature
Spawning above 68º F
Optimal for Growth 70-79 º F
Predators/Disease
.

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Temperature and Salinity:

" Of all abiotic factors … the synergistic effects of temperature and salinity probably have the most profound effects. (The two) affect virtually every aspect of oyster biology including:

- Feeding
- Respiration
- Utilization of Food Reserves
- Gonadal Development
- Time of Spawning
- Parasite-Disease Interactions
- Predation Rates
- Growth
- Distribution "

(Shumway, S. E. 1996. Natural environmental factors. *In* V. S. Kennedy, R. I. E. Newell and A. F. Eble (eds.), The eastern oyster *Crassostrea virginica*, p.467-513.

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Temperature

Spat/Seed/Adult Life stages:

Wide tolerance range with commercial concentrations of subtidal and intertidal oysters found in waters ranging from -2º to 36º degrees C.

• > 32º to 34º C (90º to 93º F) for prolonged period of days to weeks may significantly stress oysters.

- meat weight loss (yield loss)
- greater susceptibility to parasites and disease
- cell membranes become more permeable

• 0º C for several days may lead to death.

• > 40º C may lead to death. @ 49º C (120º F) may be upper thermal tolerance level for the eastern oyster.

• The rate of temperature change may be more critical than an absolute temperature. Abrupt change may be more critical than gradual change.

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Temperature

Spat/Seed/Adult Life stages:

•As temperature increases metabolic activity increases

Example: Survival of buried oysters with no oxygen

@ 25º C survived for 2 days

< 5º C survived for 5 + weeks

Larvae Life Stages:

- Less is understood about physiological and metabolic needs.
- Duration of time as larvae swimming in water is dependent on many environmental factors, but temperature is the overriding factor.

  at 25º C @ 14 days

  at 15º to 20º C @ 28 - 42 days

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Salinity

The single-most important parameter in determining the distribution of living oysters. **THE** habitat delineator.

- Basic **Physiological** Needs for survival: (no predators and disease factors)
  larvae = usually 5 - 35ppt; best >10ppt to 22ppt for metamorphosis.
  spat = 5 - 35ppt; best 10 - 30ppt
  seed/sack = 5 - 43ppt; best survival is 14 - 28ppt
  Note: in cool waters spat/seed/sack may exist in waters of near 0ppt for weeks or longer.

- Salinity influences oyster predator abundance and parasite/disease intensity.
  up-estuary → down-estuary
  inshore → offshore

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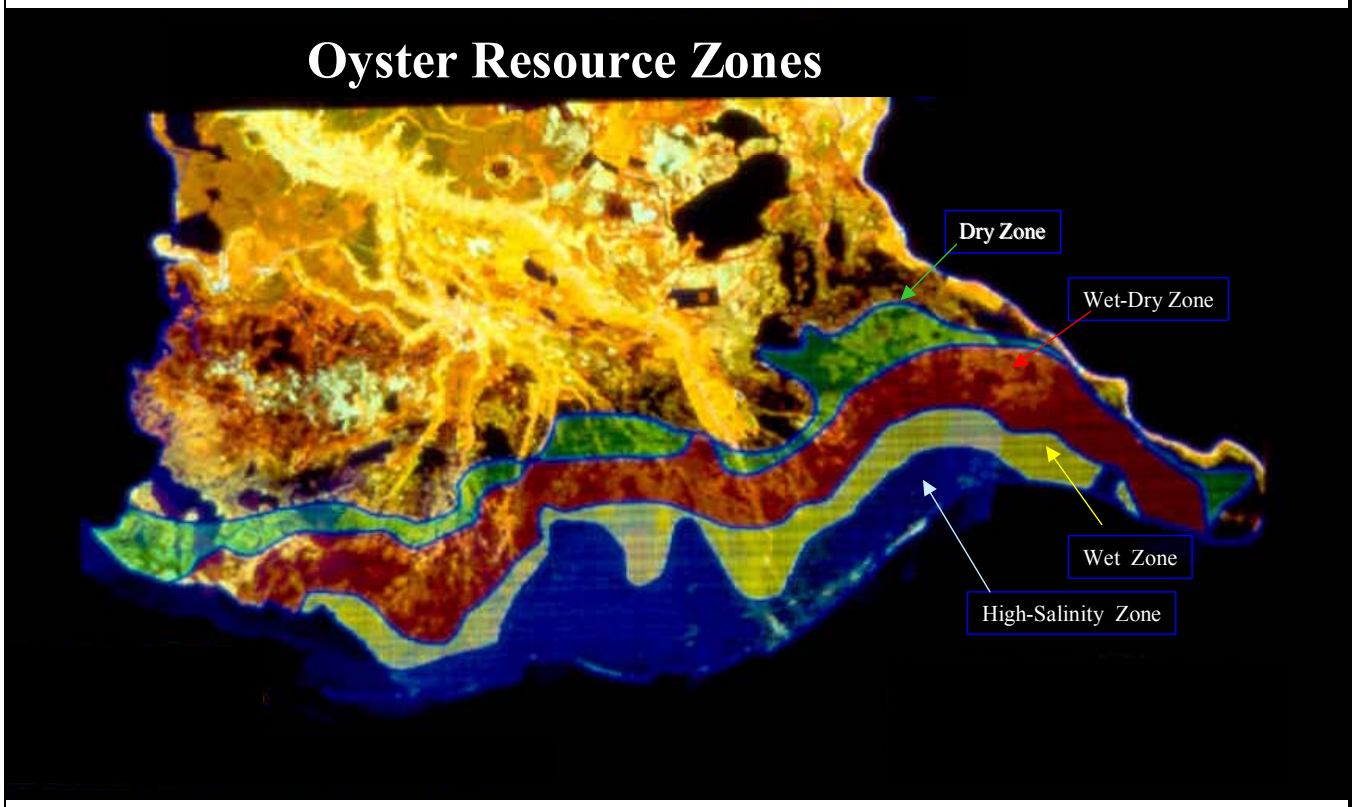

from Melancon, E. J, T. M. Soniat, V. Cheramie, R. J. Dugas, J. Barras and M. LaGarde. 1998. Oyster resource zones of the Barataria and Terrebonne estuaries of Louisiana. J. Shellfish Res., 17(4):1143-1148

This slide illustrates the locations oysters are typically found in the Barataria and Terrebonne estuaries of Louisiana under various rainfall years. Annual changes in salinities dictate the areas most favorable to oyster growth and survival.

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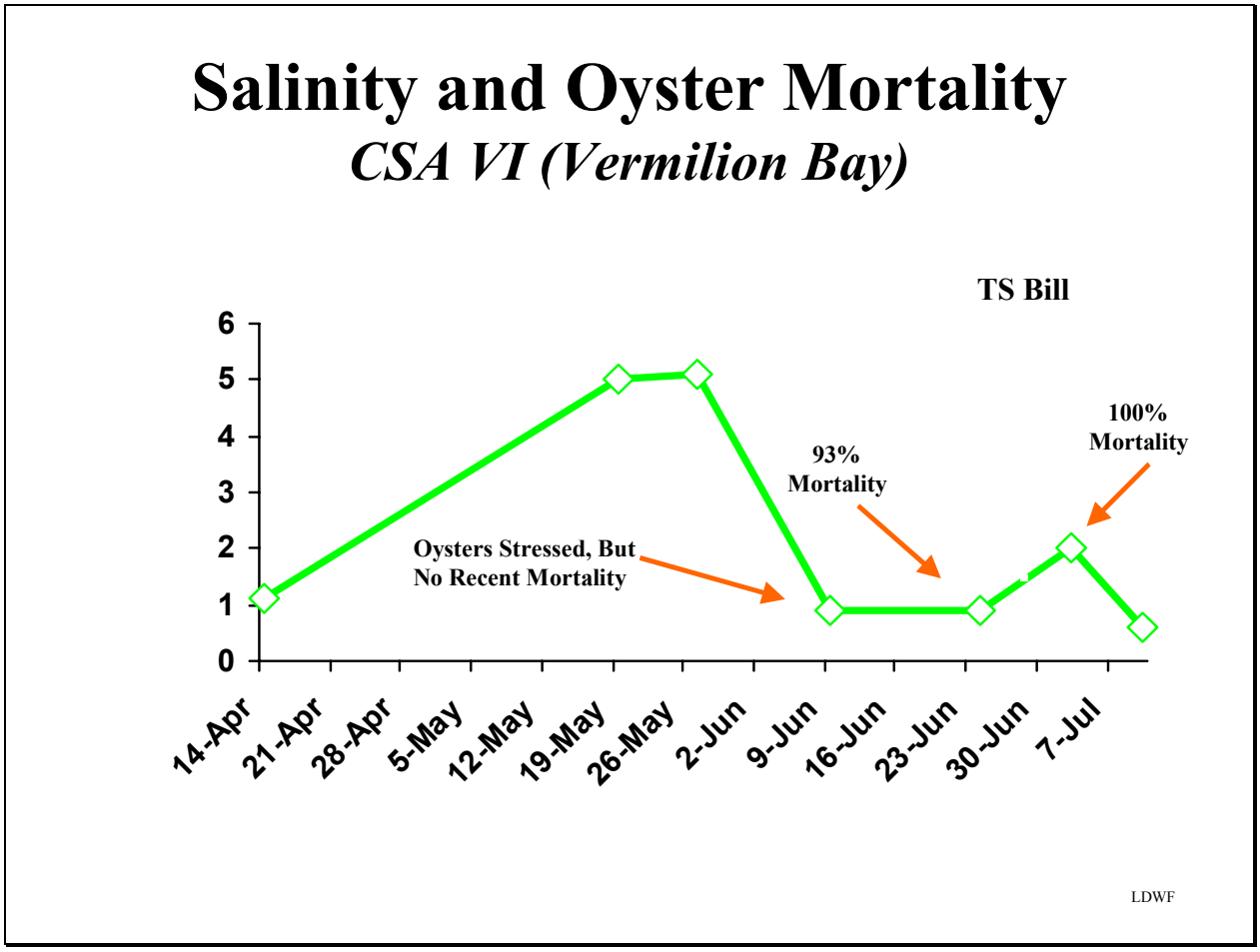

This graph shows water salinity and dates when oyster samples were collected. Oysters are generally able to withstand very low salinities for about two weeks before dying. This chart also shows that massive mortalities occurred prior to Tropical Storm Bill's impact on the area. Even though T.S. Bill was not the cause of the majority of the oyster mortalities, a a natural disaster to the oyster resources due to flooding did occur in this area. The soonest this area could have marketable oysters again under favorable conditions would be in 18-24 months.

Growth Rate

- Depends on environmental conditions
  - Faster at warm temperatures, high food concentrations, faster water flow
  - Slower (or stops) at colder temperature, low food concentration
- Size is relative with regard to environmental conditions

Growth

- Difference in growth rate results in difference in commercial production
  - East and West coasts-up to 3 years to market size
  - Gulf coast-as little as 6 - 9 months
- Changes in environmental or physiological conditions can take a greater toll on slower growing populations (disease, predation)
- Genetic engineering has resulted in increased growth rate and disease resistance

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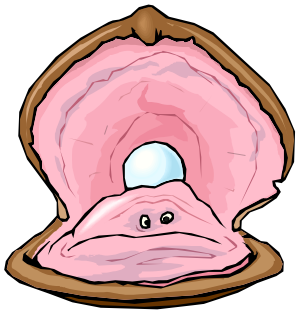
Oysters are at the Mercy of their Surrounding Environment

- Parasites
- Diseases (MSX, Dermo)
- Adverse environmental conditions (drought, flood, siltation, dredging, famine, extreme heat/cold)
- Pollution



Oysters have no choice of habitat once they have attached to suitable cultch material. The water that surrounds them must provide for all their needs if they are to survive and grow.
Oysters must filter water to:
Eat
Breath
Reproduce
Filtering water is a function of the mantle and gill (siphon)
Oysters filter large quantities of water each day
Oysters act as 'bio-filter' for surrounding water

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An inter-tidal oyster reef exposed at low tide.

An inter-tidal oyster reef exposed at low tide. While this can help protect the oysters from some predators, it exposes them to others. Inter-tidal oyster reefs are especially vulnerable to freezing during extended freezes. Entire reefs such as this one may suffer 100% mortalities due to freezing.

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Water Flow

- Oysters are stationary organisms
- Rely on water flow to bring food and oxygen to them
- Tides (intertidal, subtidal)
- Currents

These intertidal oysters depend largely on daily tidal cycles for their survival.

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Water Flow

- Supplies and replenishes food
  - dense populations can deplete food from slow moving water
  - at fast flow rates, removal of food becomes inefficient
  - water flow re-suspends food from benthic layer
- Supplies and replenishes oxygen
- Disperses larvae
- Removes metabolic waste

The flow of water over the oyster reefs must be adequate for many reasons.

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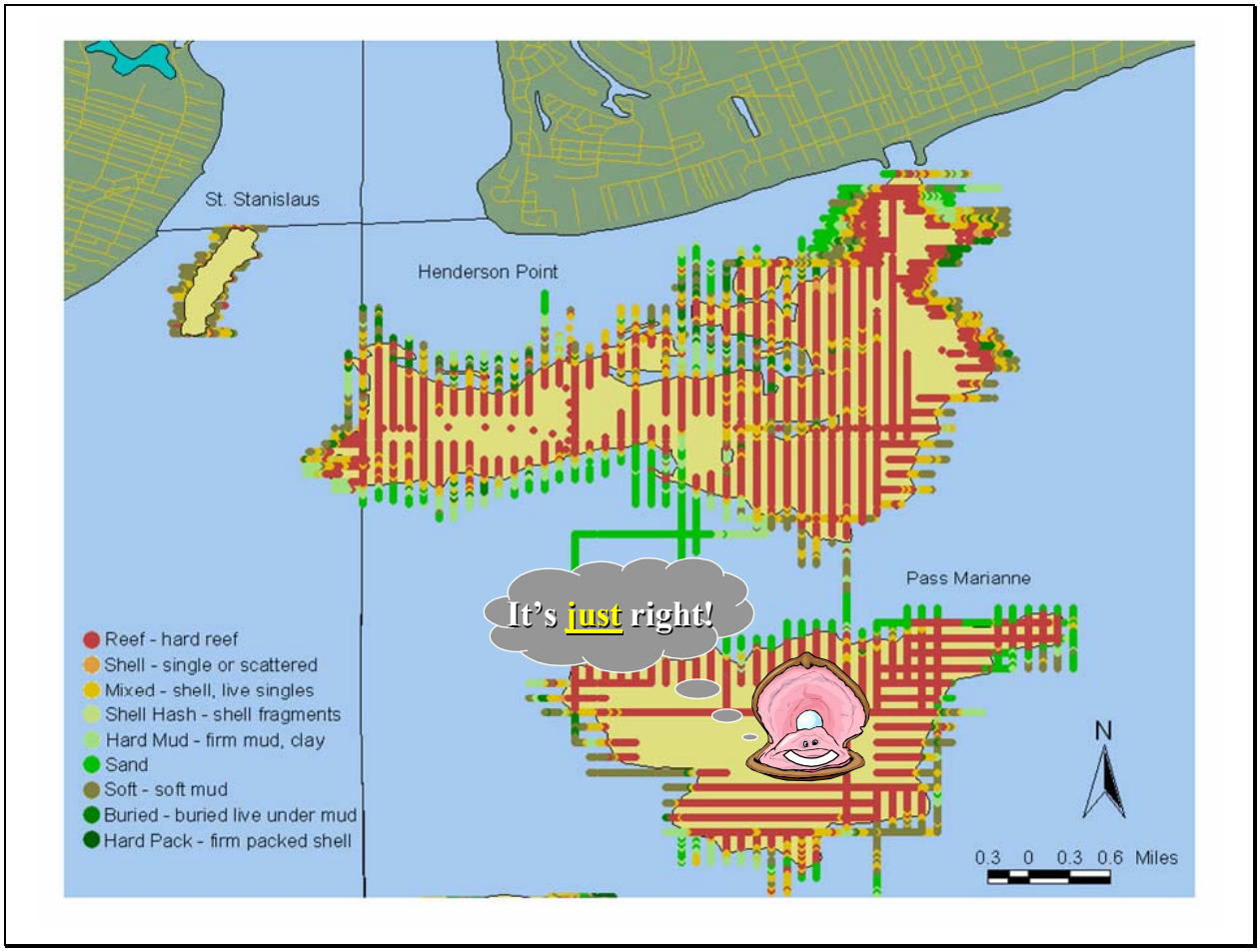

Substrates

If proper substrate is not available, larvae will die. Oysters growing on a soft mud bottom will gradually sink into the mud as they gain weight. Moving sand can bury a reef.

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The Way Oysters Eat

- Oysters are filter feeders
- If pathogens or contaminants are present in their environment, they will take them up

Oysters are filter feeders
Pass water over gills
Particles are sorted (palps, gills; feel, size, composition)
Remove particles from water (organic, bacteria, virus, dirt)
Food particles to digestive system; others become pseudofeces

A large adult oyster has the ability to pump a maximum of around 5 gallons of water per hour and 50 – 60 gallons per day!

Bio-Accumulation
Filter particles out of the water
Accumulate whatever is present in the water
Hold in tissues
biotoxins
environmental contaminates
pathogenic microorganisms
This is one of the reasons water quality is so critical to oysters, especially those destined for human consumption. Furthermore, many consumers eat oysters uncooked.

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Filter Feeding and Food Safety

Because oysters accumulate and concentrate pathogens and contaminants through filter feeding water quality in growing areas must be low in pathogens and contaminants

Frequent water sampling of oyster growing areas is just one of the many tools used by managers to ensure a safe and wholesome product reaches the consumer.

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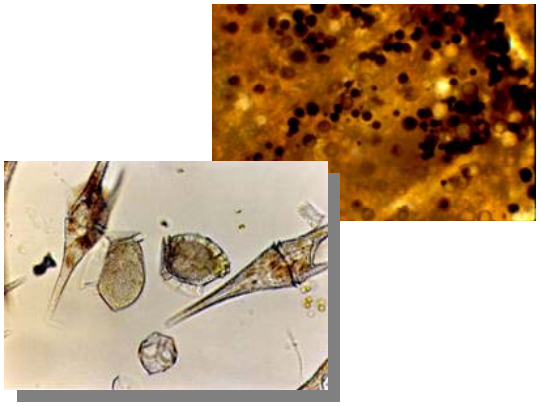
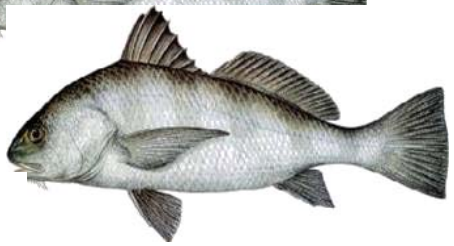
Predators/Diseases





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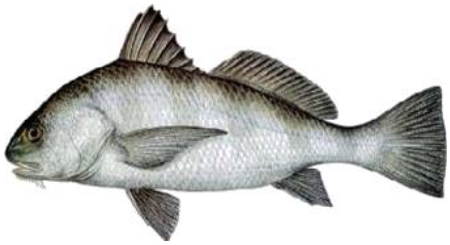
Predators

starfish

black drum



crabs

oyster drill

Predator control is very important in oyster aquaculture. If there is no predator control, they will rapidly decimate an oyster population. There are few effective methods to control these predators in the wild. Fortunately, many of these predators are controlled naturally by lower salinities.

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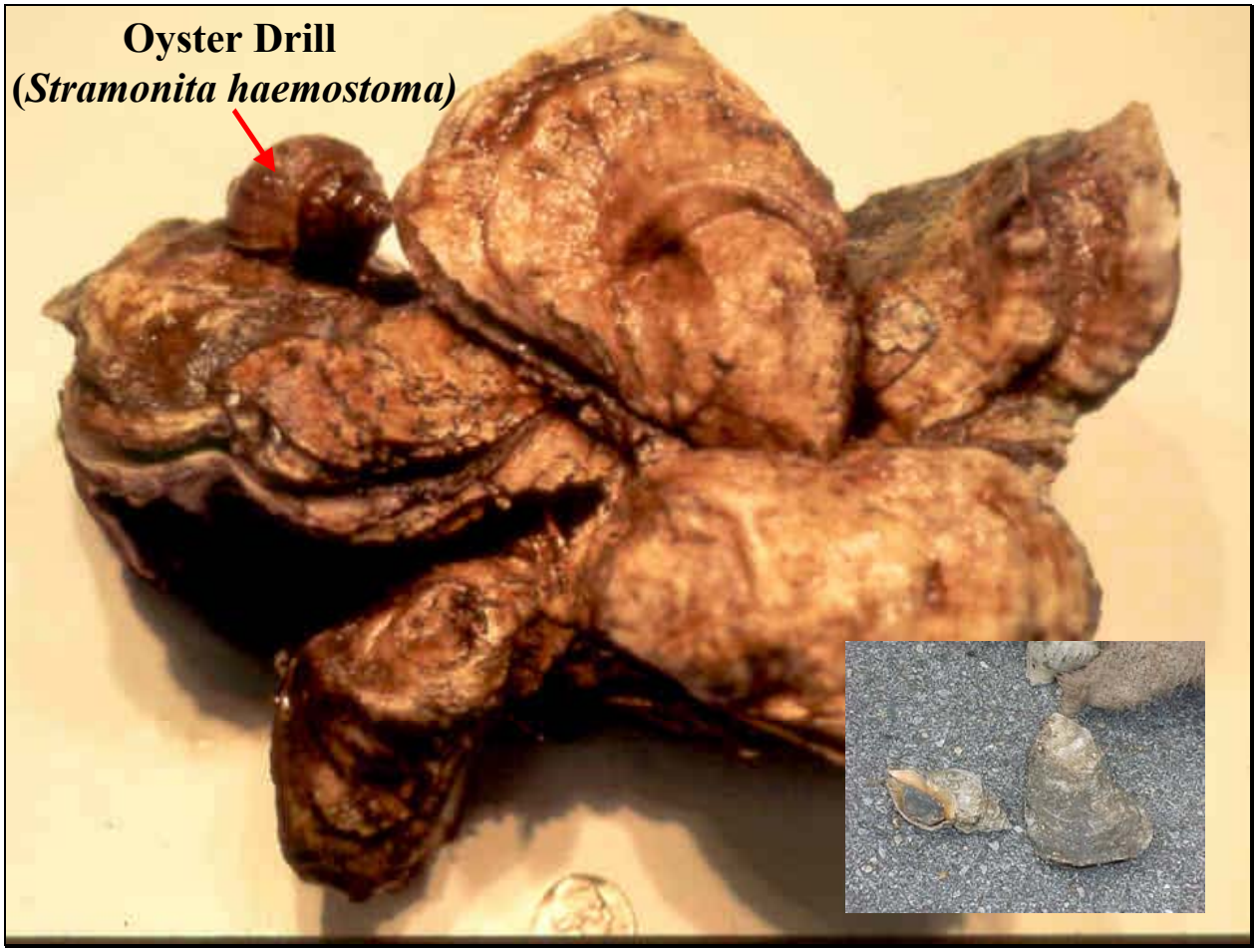

An oyster drill “drilling” a hole in an adult oyster shell. Oyster drills typically prefer higher salinities. By moving into an area in large numbers, they can quickly decimate an entire reef.

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Phylum Mollusca

Class Gastropoda

Stramonita haemostoma (oyster drill)

> 15ppt
radula
@ 70mm max length
mate and spawn spring-summer
Lay egg capsules in clusters
on vertical structures
each capsule@100 larvae

The lower right hand photo illustrates oyster spat that have set on the shell of an oyster drill.

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***Perkinsus marinus* (Dermo)**
hypnospores

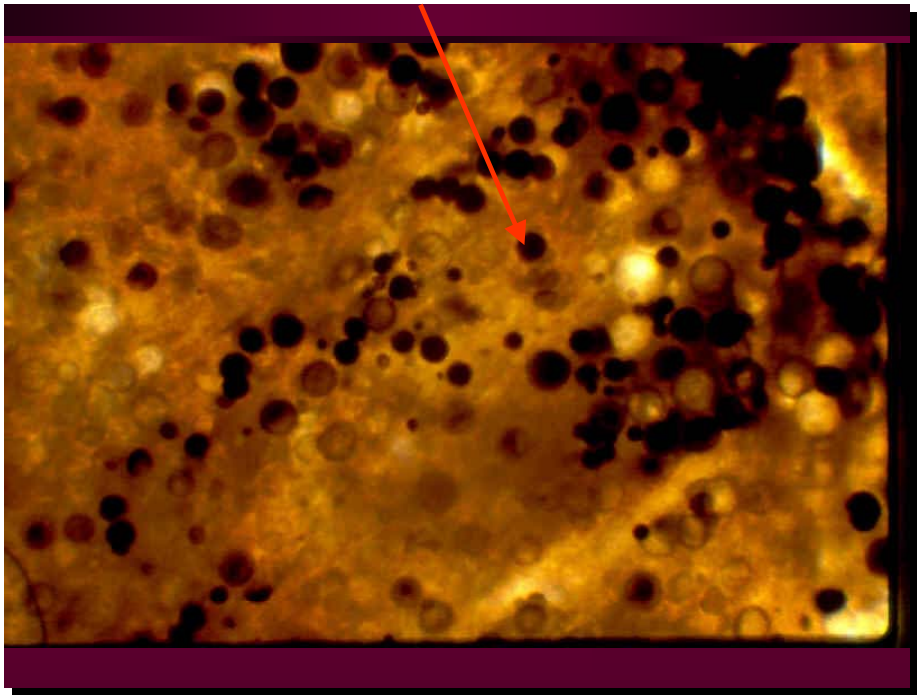

photo Julie Gauthier

Count Number of Spores per Microscope Field of Vision for Infection Intensity

Dermo is a disease of oysters that may result in high mortality rates in oysters. Elevated water temperatures and salinities usually facilitate these mortalities.

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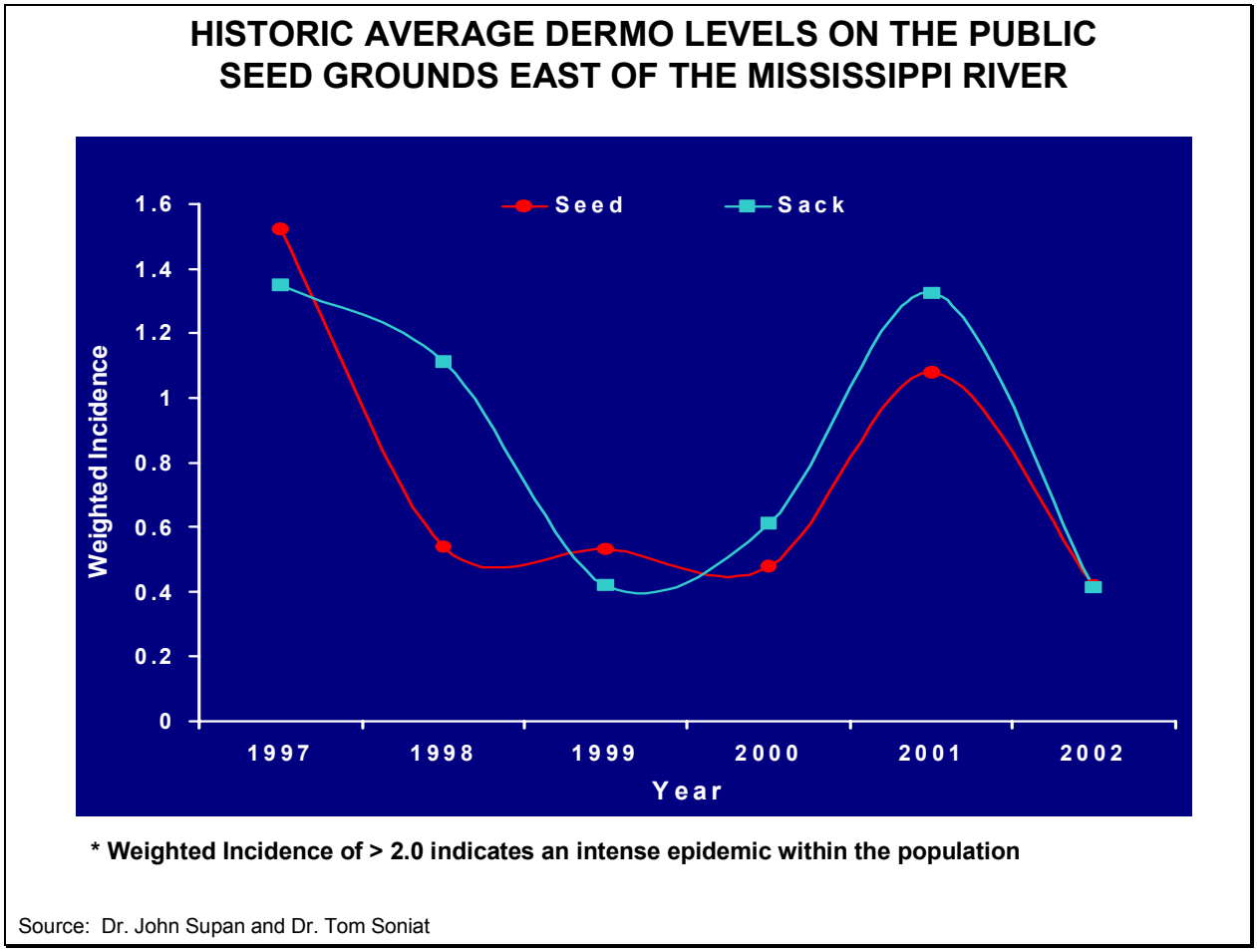

Fluctuations in DERMO levels in Louisiana.

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Black Drum

Pogonias cromis

Large schools of black drum feed on oysters of all sizes. Black drum use a special set of teeth to crush the shell. They can cause significant losses to oyster reefs.

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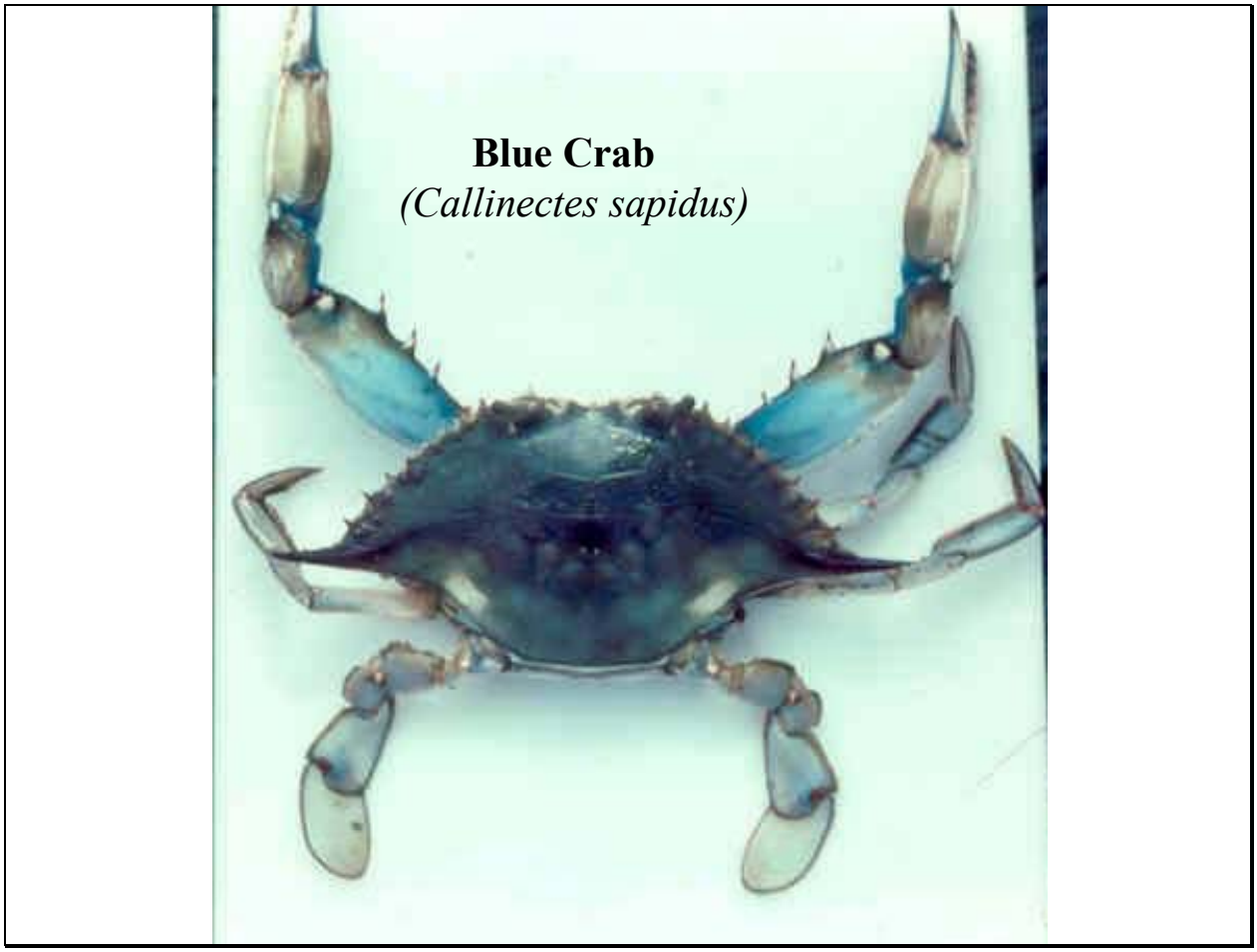

Crabs often feed on oysters. Typically, mortalities associated with crabs are not as significant as those caused by other factors.

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Shell Damage Caused By Boring Clams and Sponges

This oyster shell is riddled with holes caused by boring clams and sponges. These organisms occur in their highest numbers at elevated salinities. They may cause extreme damage to the shell, weakening this defense of the oyster against other predators, and causing the oyster to expend energy to repair the damage inside the shell.

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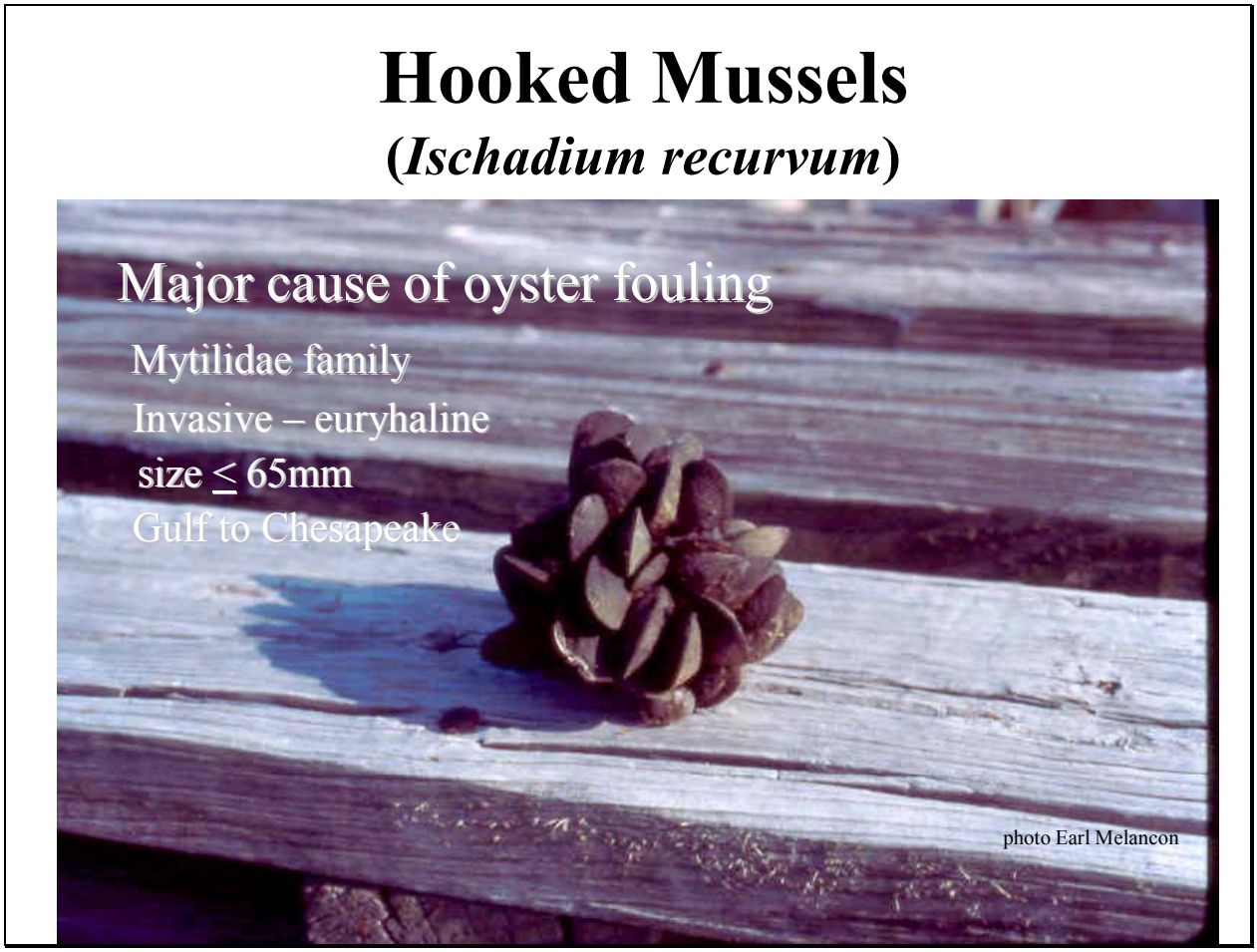
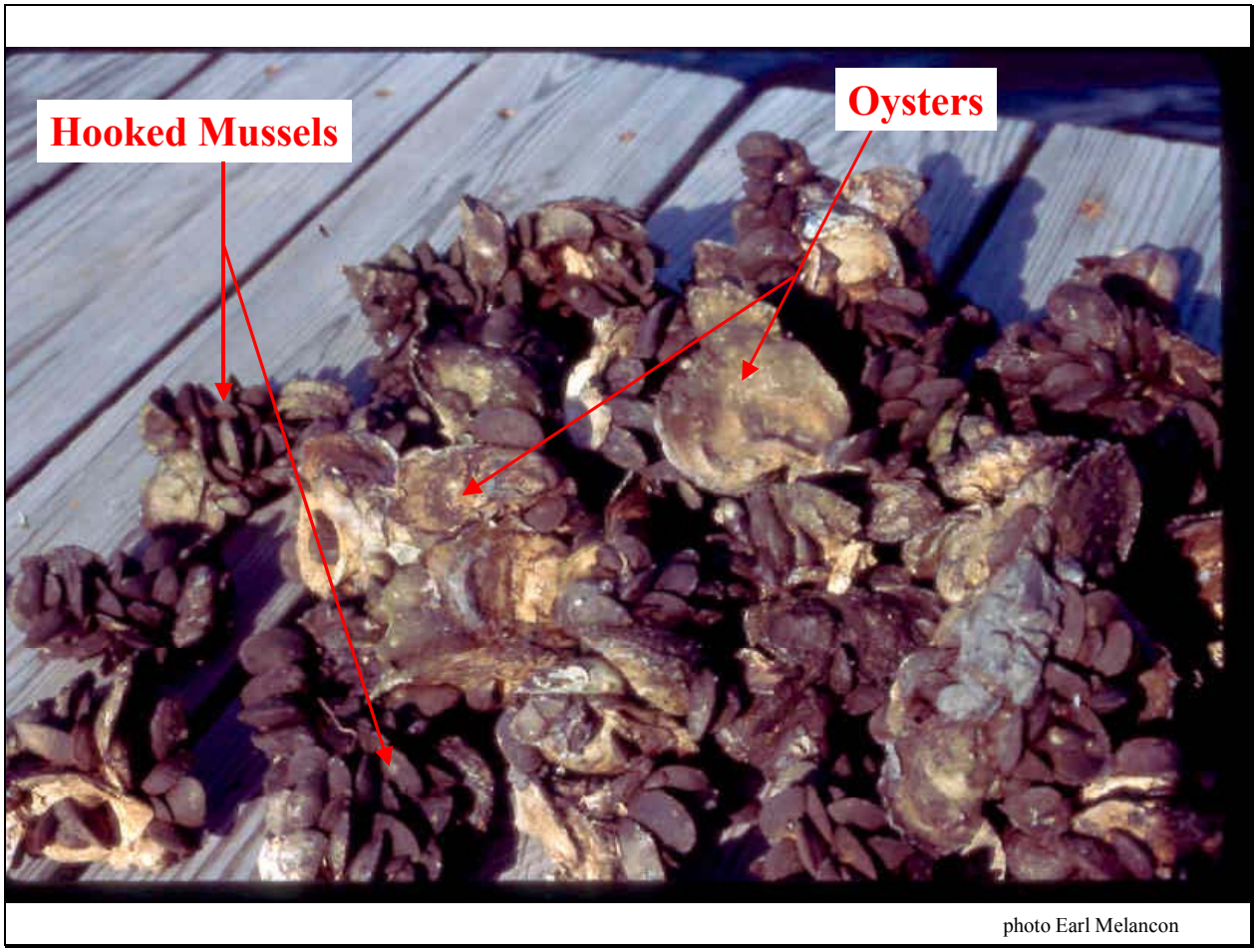


Hooked mussels compete with oysters for food and space. There was an oyster in the center of this cluster of hooked mussels. Fortunately, most predators find the thinner shells of hooked mussels easier to overcome than the thick shelled oysters.

Slide 47



Oysters moderately infested with hooked mussels.

Slide 48

Fouling Organisms

Fouling organisms such as these barnacles compete for space and food with oysters and may restrict water flow to the oyster.

Fouling must be controlled in order to provide the oysters with maximum food intake. Once again, this is a costly part of oyster culture and more efficient methods to control fouling is constantly being explored. In the wild, barnacles are usually controlled by salinities less than 10ppt.

Slide 49

The ISSC's Model Ordinance specifies **water quality criteria** for the classification of shellfish growing waters.

Shellfish Growing Water Major Classification Types:

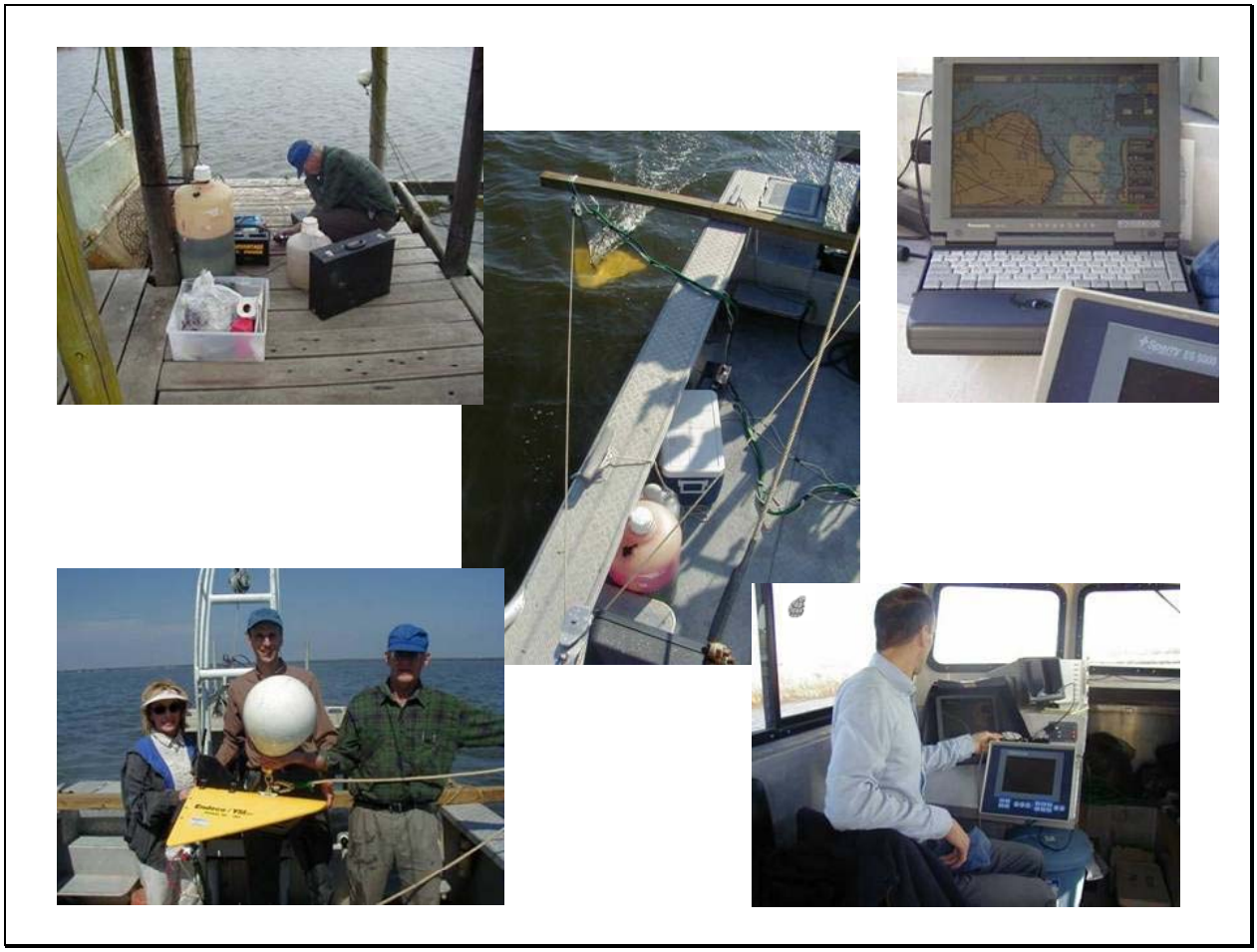
"APPROVED AREA" - Waters where the growing and harvesting of shellfish for direct marketing is allowed.

"CONDITIONALLY APPROVED AREA" - Waters that meet approved area criteria for a predictable period. The period is conditional upon established performance standards specified in a management plan. A conditionally approved shellfish growing area is a closed area when the area does not meet the approved growing area criteria. (Usually based on riverstage or rainfall.)

"RESTRICTED AREA" - Closed area waters from which shellfish may be harvested only if permitted and subjected to a suitable and effective purification process.

"PROHIBITED AREA" - Waters that are prohibited for the harvest of shellfish for any purpose except depletion. A prohibited shellfish growing area is a closed area for the harvesting of shellfish at all times.

Slide 50



Hydrographical Study

Hydrographic studies are used to determine movement of water and possible pollutants and the dilution rates. This is useful in determining the closure areas required for shellfish growing area classifications.

Top Left: A precise quantity of rhodamine dye is injected into the body of water being studied
Bottom left and center: A probe that can be towed in the water behind a boat collects water temperature, depth and pumps water samples to the surface.
Right top and bottom: a laptop computer on the boat is connected to dye sensors and a global positioning system (GPS) and collects a permanent record of the geographically referenced results.

Slide 51

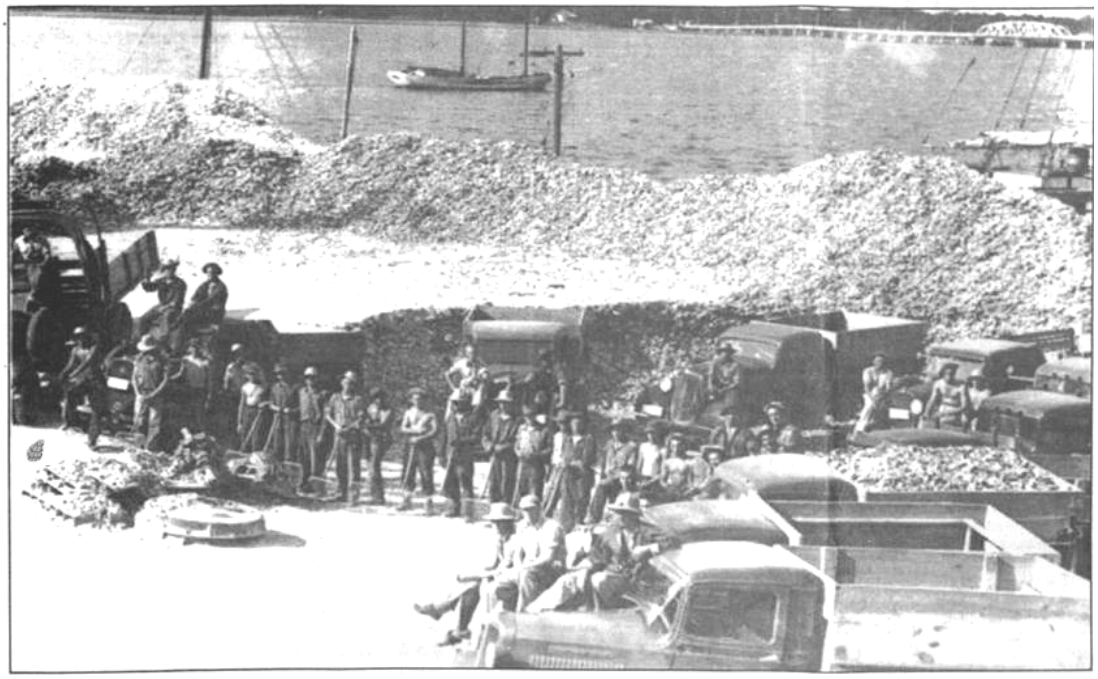
Habitat Creation

A new oyster reef is born.

Slide 52

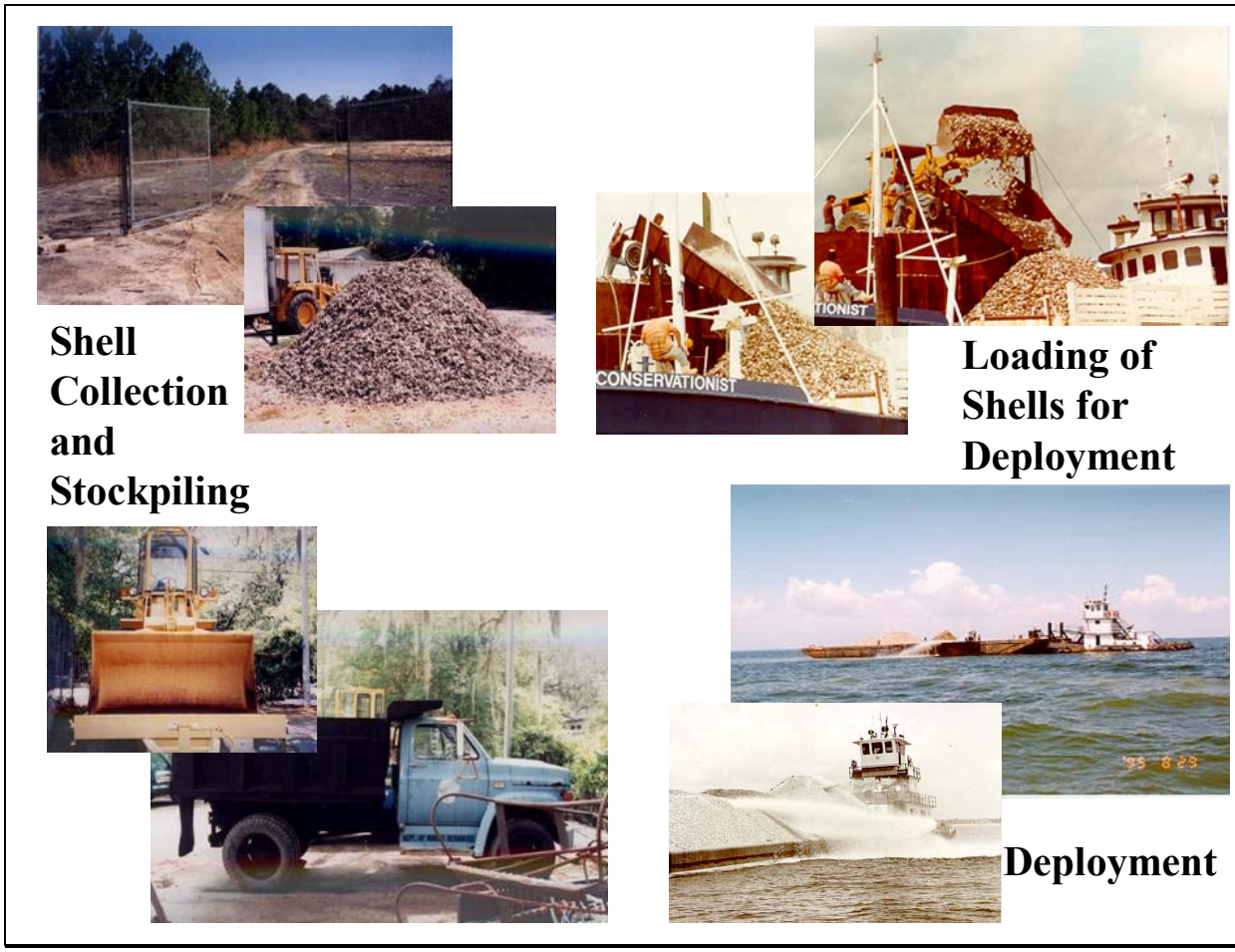
Oyster Shell Reclamation Crew in 1930's Biloxi

(*Sun-Herald* Staff Photo)



Oyster shells continue to be a much sought after commodity. They are especially useful as a cultch material for the creation or rehabilitation of oyster reefs. Other uses of oyster shell includes poultry feeds, calcium supplements, road fill material and in the processing of aluminum ore.

Slide 53



Although modern equipment may make the job somewhat easier, the principle remains the same... using cultch material for the creation or rehabilitation of oyster reefs.

Slide 54

Shell Planting

Providing oyster shell cultch for new spat set on reefs. This operation is conducted in the spring or fall to coincide with peaks in the spawning periods. Cultch material; typically oyster shell, limestone or crushed recycled concrete; are blown off barges with high pressure water cannons. The barge is moved over the selected site by a tugboat, aided by a GPS plotter. Spat attached to a shell (top right) are 1-2 months old. A cluster of young oysters from an oyster cultch plant are shown at the bottom right.

Ecological Values of Oyster Reefs
The "coral reefs" of estuaries
Support some 300 species of aquatic plants and animals
Water filtering abilities
Indirectly removes nutrients

Slide 55


•Mississippi uses cultch plants to augment natural reef production.
•Shell retention fees collected from harvesters and dealers help fund cultch plants.

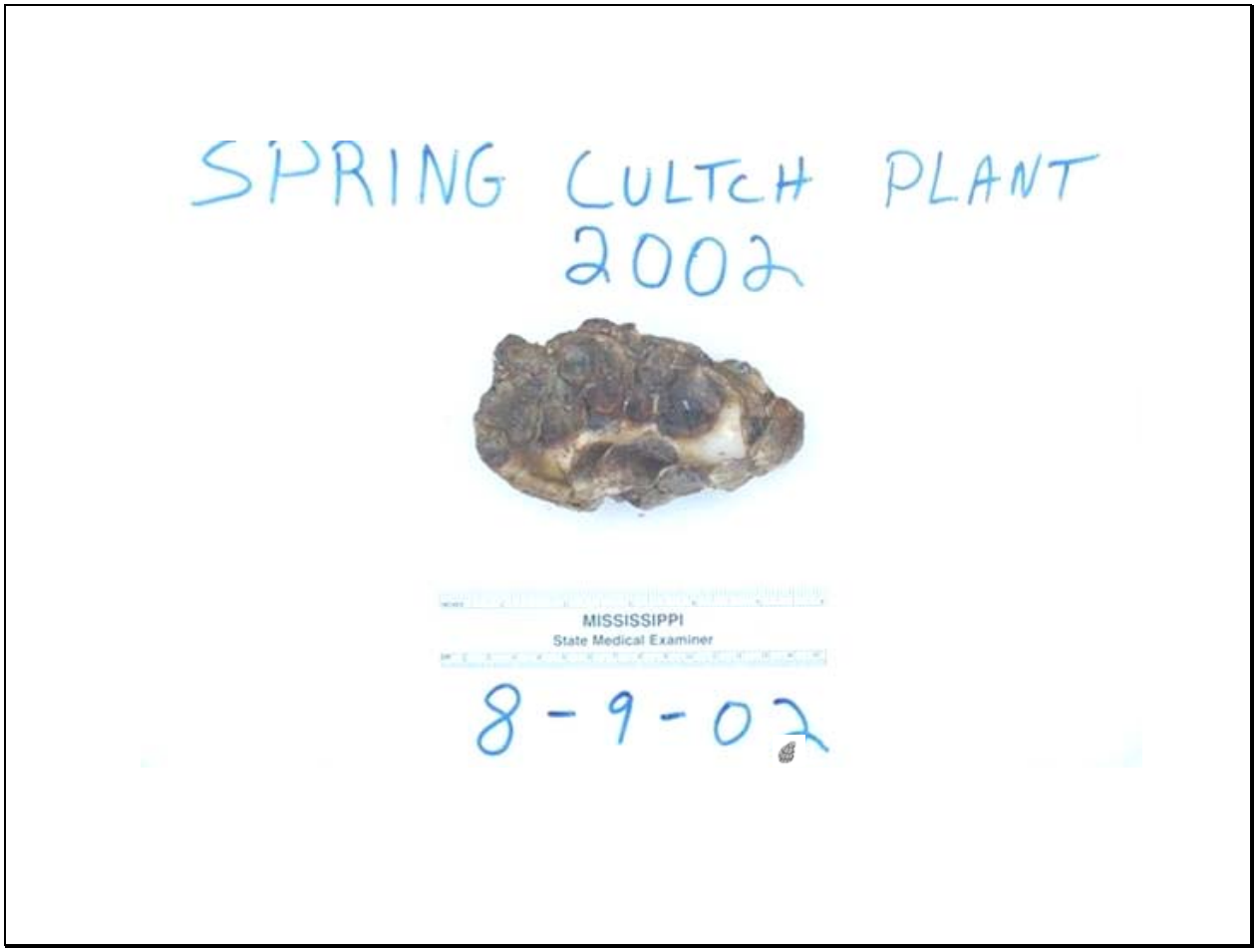
Slide 56

Mississippi Reef Acreage Developed Since 1997

Year	2002	2001	2000	1999	1998	1997
Acres	160	100	165	20		300

- Created 745 acres of new or improved reefs.
- Total cost in excess of 1.41 million US dollars

Slide 57



This image shows an oyster shell approximately two months after a cultch plant. The shell is covered with numerous oyster spat.

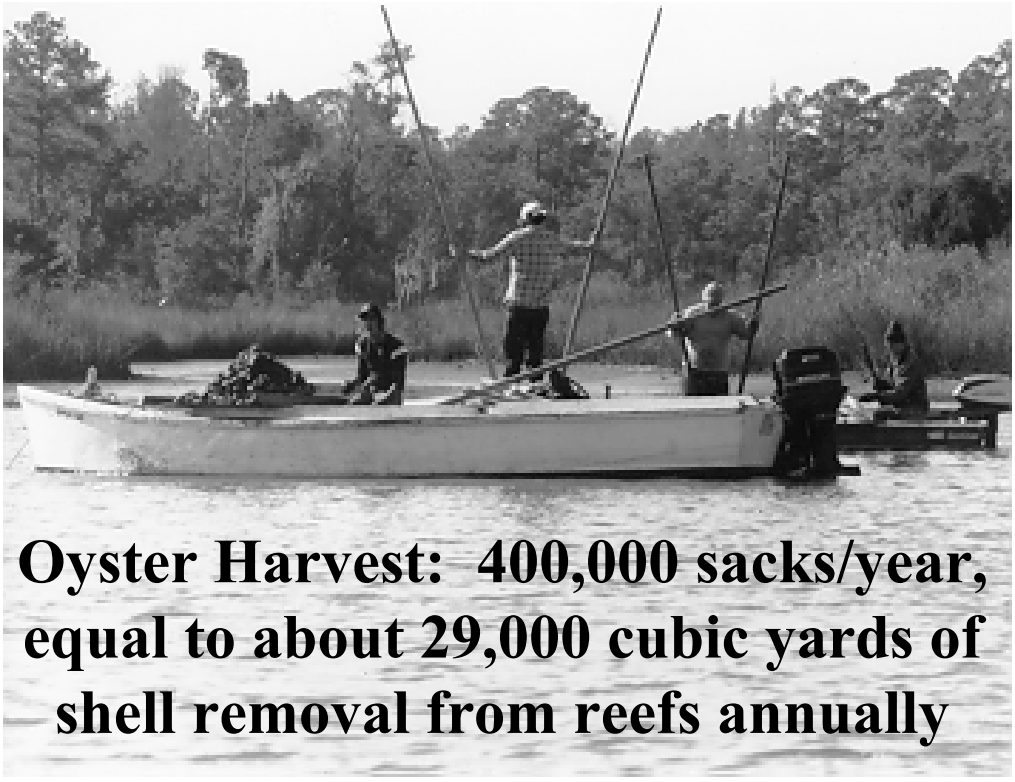
Slide 58

This image shows an oyster shell approximately 14 months after a cultch plant. The shell is now the base for a cluster of oysters. Dredging or cultivation of this reef will help break up this cluster and help the reef grow into a new “oyster bed.”

Slide 59


Oyster Reef Revitalization
PRIORITY ONE?
Since 1980, Mississippi has deployed nearly a quarter of a million cubic yards (250,000 yd3) of cultch material to revitalize oyster reefs...

Slide 60


Oyster Harvest: 400,000 sacks/year, equal to about 29,000 cubic yards of shell removal from reefs annually

Other Habitat-Related Issues of Concern Include:

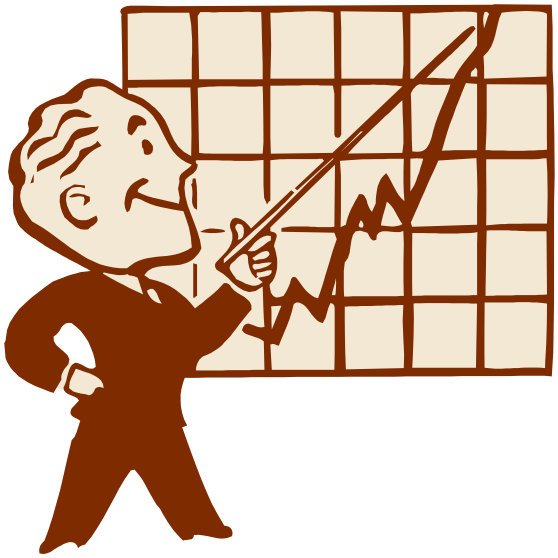
- Dredging, filling, excavation, mining, impoundment, discharge, water diversions, thermal additions, actions contributing to non-point source pollution and sedimentation, introduction of hazardous materials, introduction of exotic species, and the conversion of habitat that may eliminate, diminish, or disrupt its ecosystem functions.

Slide 62

Planting oyster cultch material from a barge in view of the Statue of Liberty in New York. I couldn't resist including this slide!

Slide 63

Resource Assessment

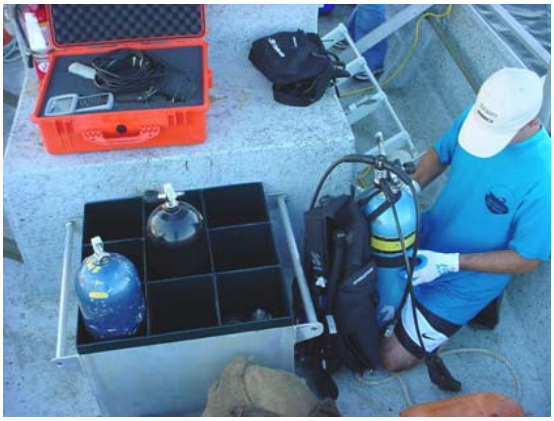


Question: How do you know what is there?
Question: What is alive?
Question: What may have caused any mortalities?
Question: How much is available for harvest?
Question: What has been harvested?
Question: What should be available next year?

Answer: You do a resource assessment.

Slide 64

Biological Monitoring



Goal: Monitor the overall size, health and condition of oyster resources

Dredge Samples Samples	Square Meter Samples	Hydrological Samples	Dermo
• Mar - Oct	• Jun - Jul	• Taken at each sampling station	• Jun - Jul

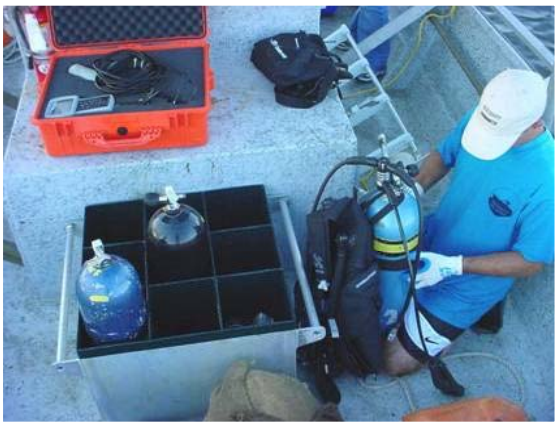
LDWF

Louisiana's biological monitoring program for oysters.

Slide 65

Methods

- ✓ Sample Collection
  - Performed in June/July
  - Quantitative (m^2)
  - ~ 190 samples
  - SCUBA



- ✓ Sample Analysis
  - Oysters divided into seed and sack sizes
  - Qualitative data on oyster predators also gathered
- ✓ Stock Assessment Report
- ✓ Season Recommendations Developed

LDWF

Some of the methods used in Louisiana's biological monitoring program for oysters.

Slide 66

HARVEST MONITORING

Goal: To measure oyster resource utilization levels by fishermen

Boarding Reports

- **Fishing effort and harvest surveys**
- **Time/Temperature log books**

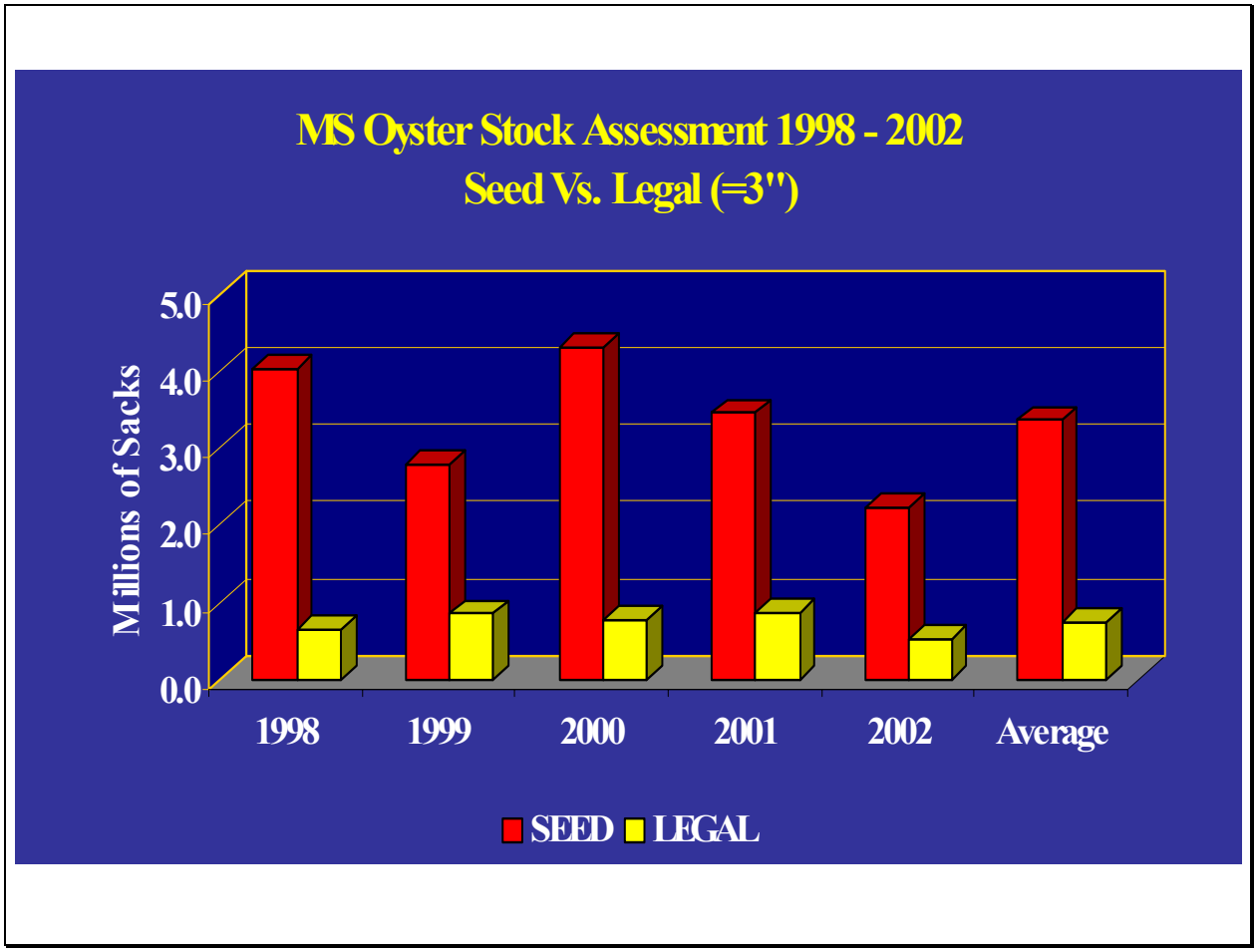
Trip Ticket Reports

- **Transaction records at first sale**

LDWF

The collection of harvest data is important in order to monitor both current conditions as well as historical trends. This information may be used for many purposes (e.g. biological studies, economic studies).

Slide 67



An Oyster Stock Assessment of Mississippi Major Reefs.

Slide 68

Logo's of some of the state agencies responsible for managing the oyster harvest and shellfish sanitation programs in the Gulf of Mexico.

Slide 69

Managing the Resource

Alabama

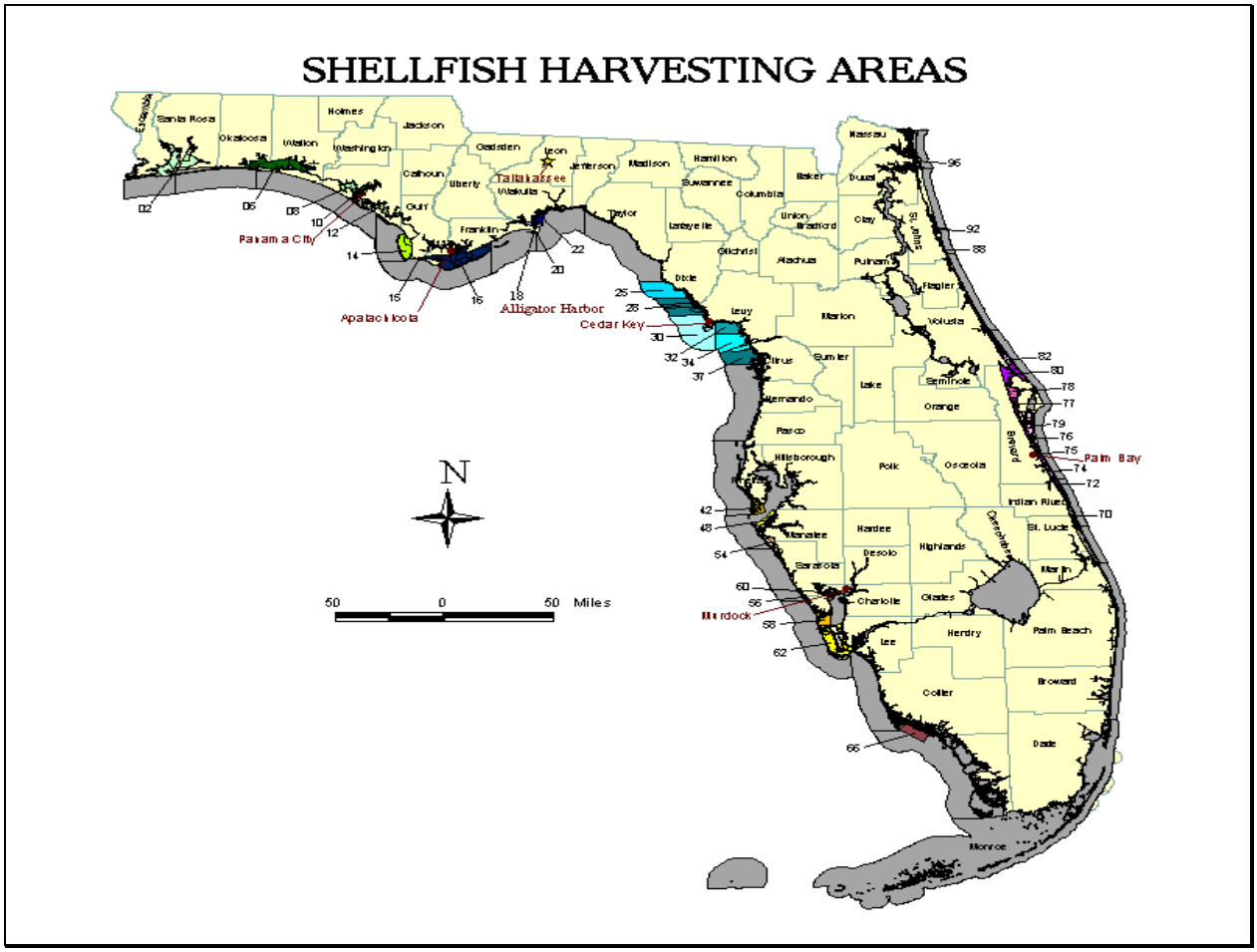
- State requires that harvested shell be returned
- State gathers oyster shell from shucking shops and "plants" shell in public waters
- Catchers harvest oysters
  - Tongs only
- Leases of public bottoms available. Lease holder responsible for planting shells or seed oysters. No public source of seed oysters.

This is an example of how the State of Alabama manages their oyster resources.

Slide 70

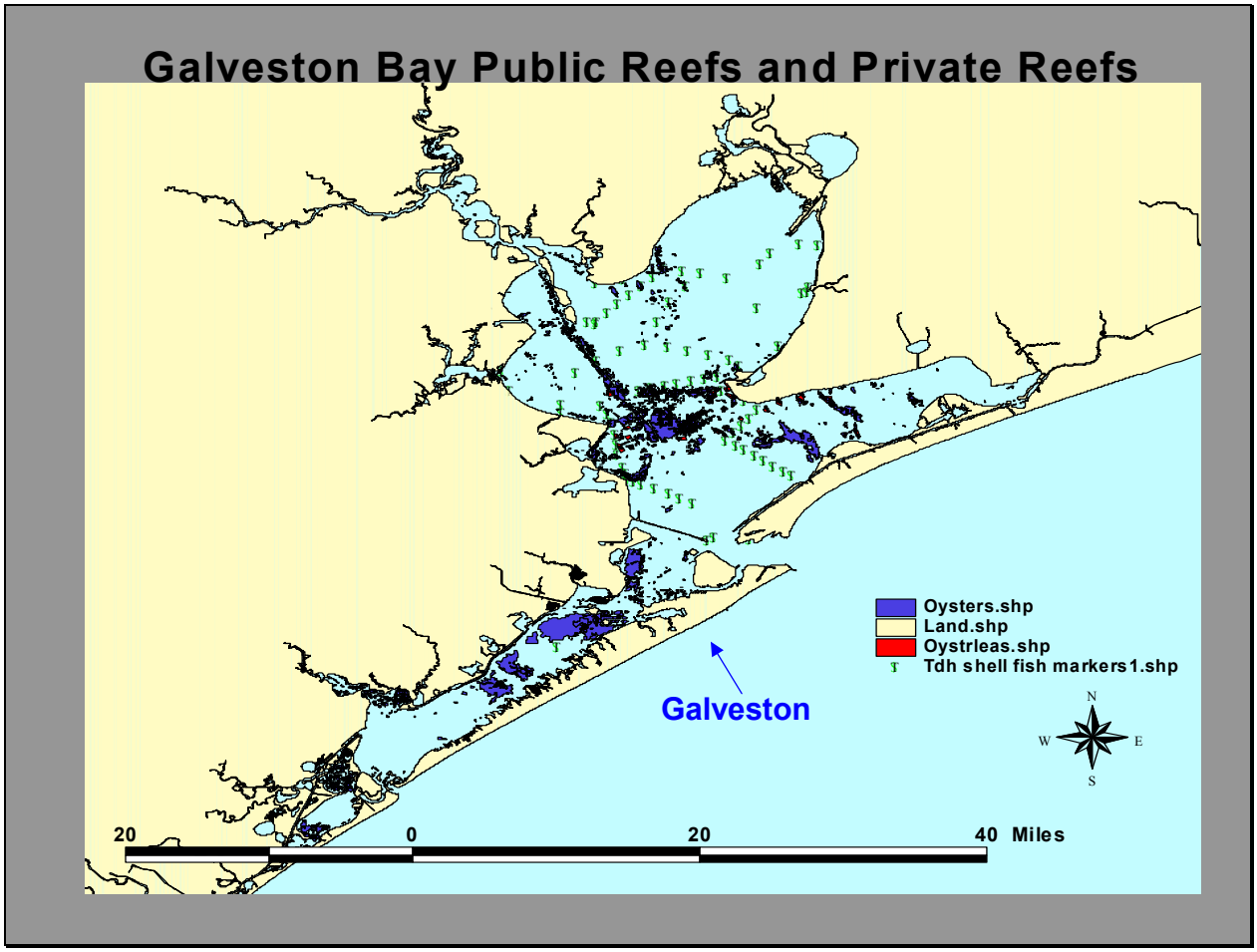
Major Alabama Oyster Harvest Areas of Mobile Bay.

Slide 71



Florida Shellfish Harvest Areas.

Slide 72



Some of the major oyster areas of Texas.

Slide 73

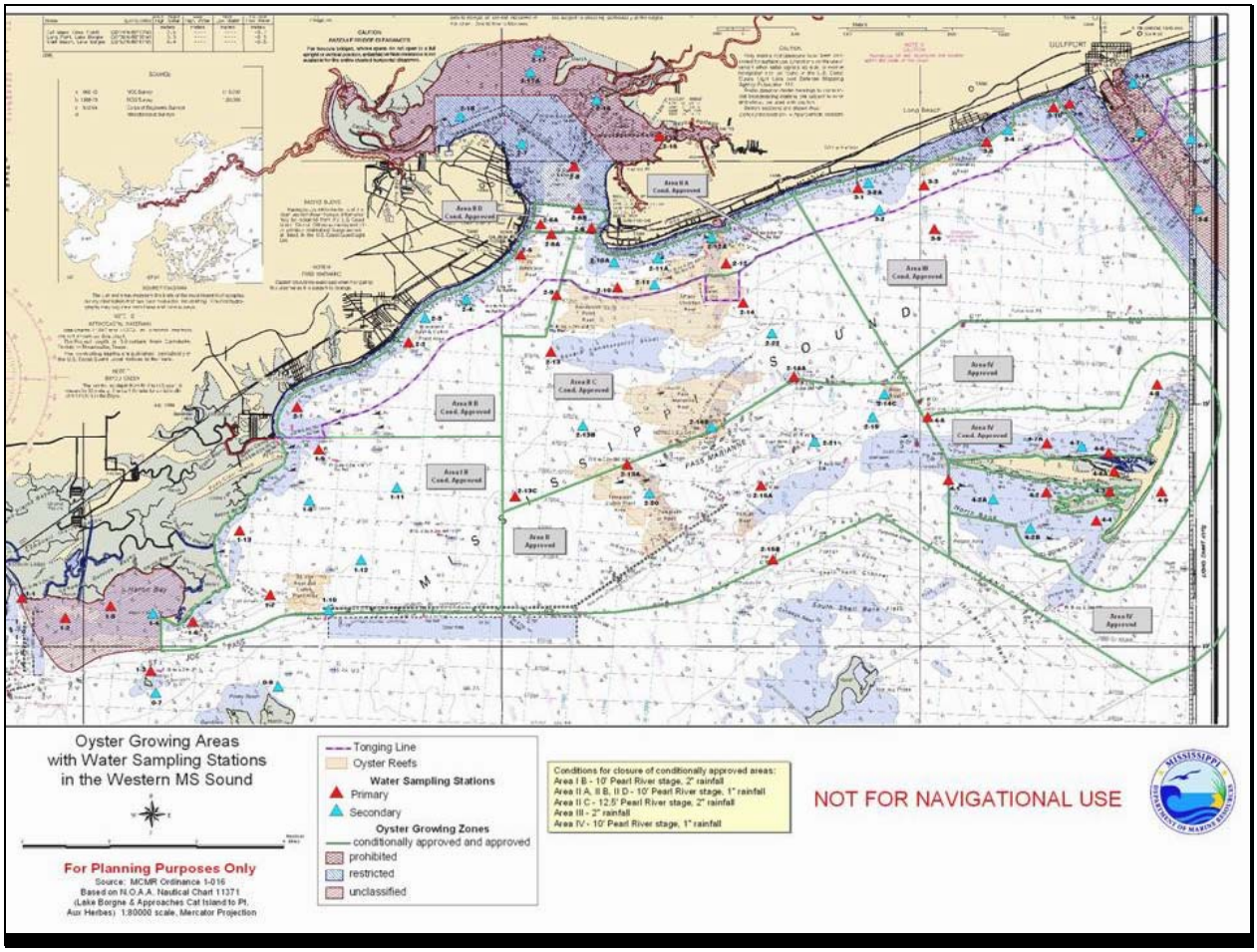
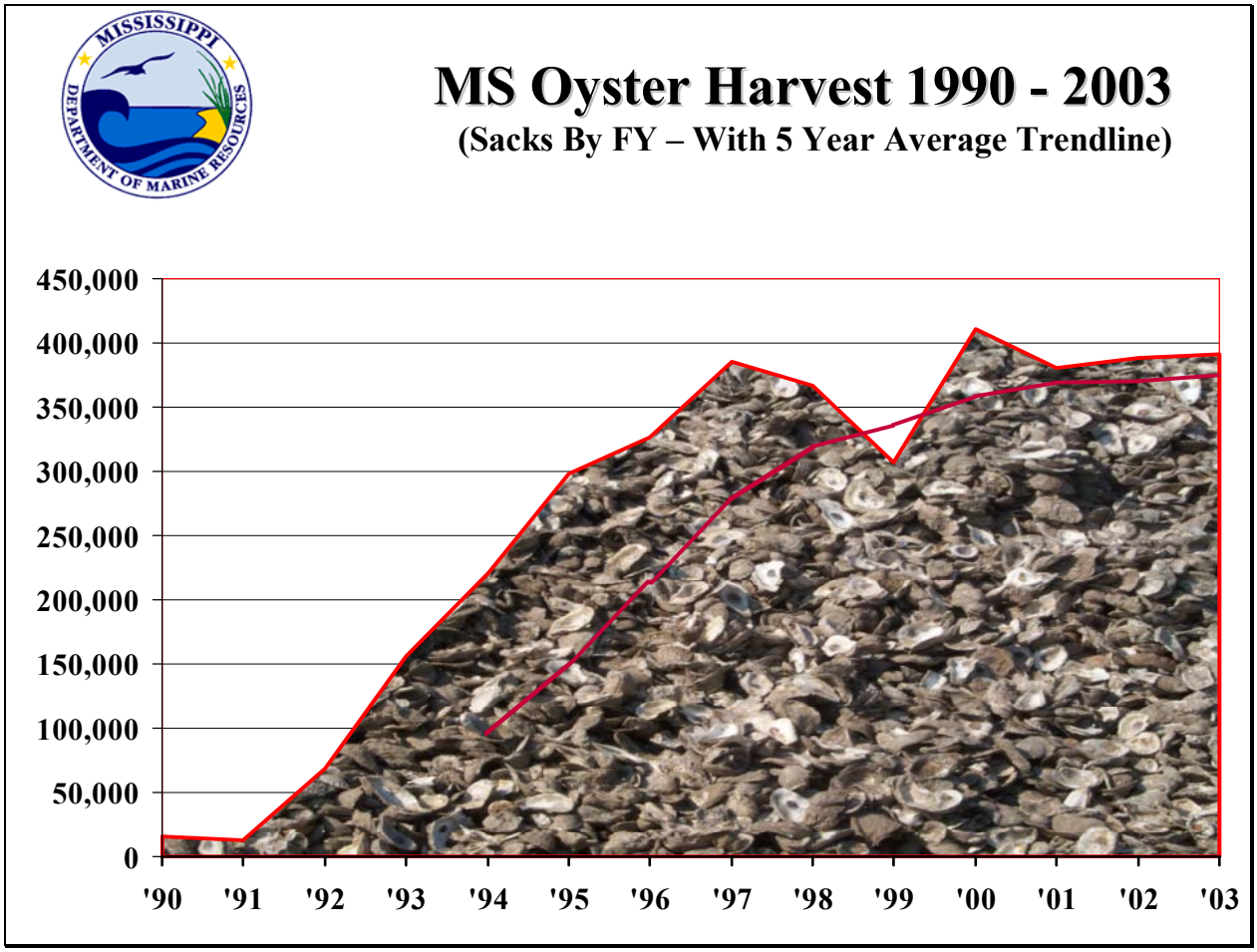
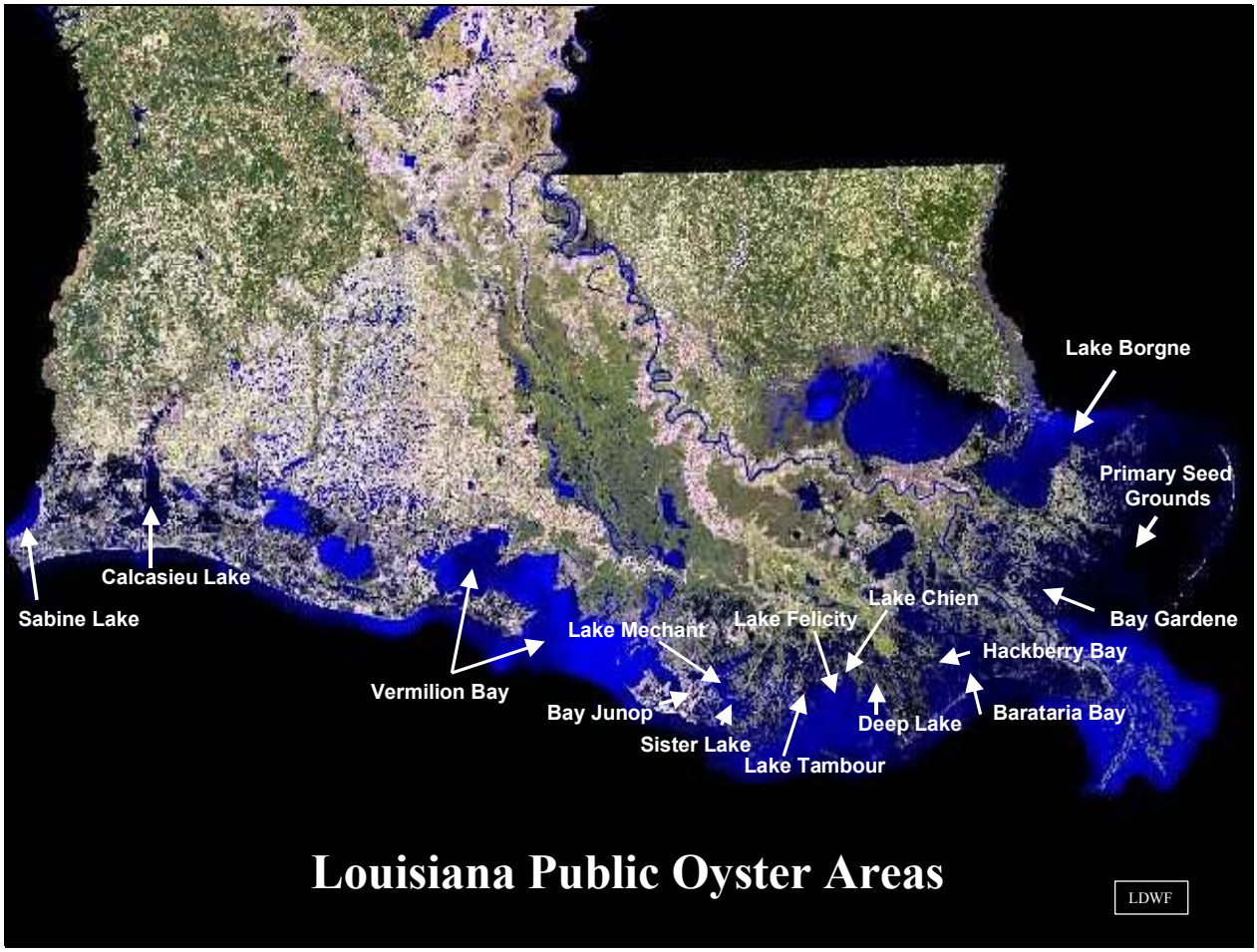


Chart of the major oyster areas in the western Mississippi Sound.

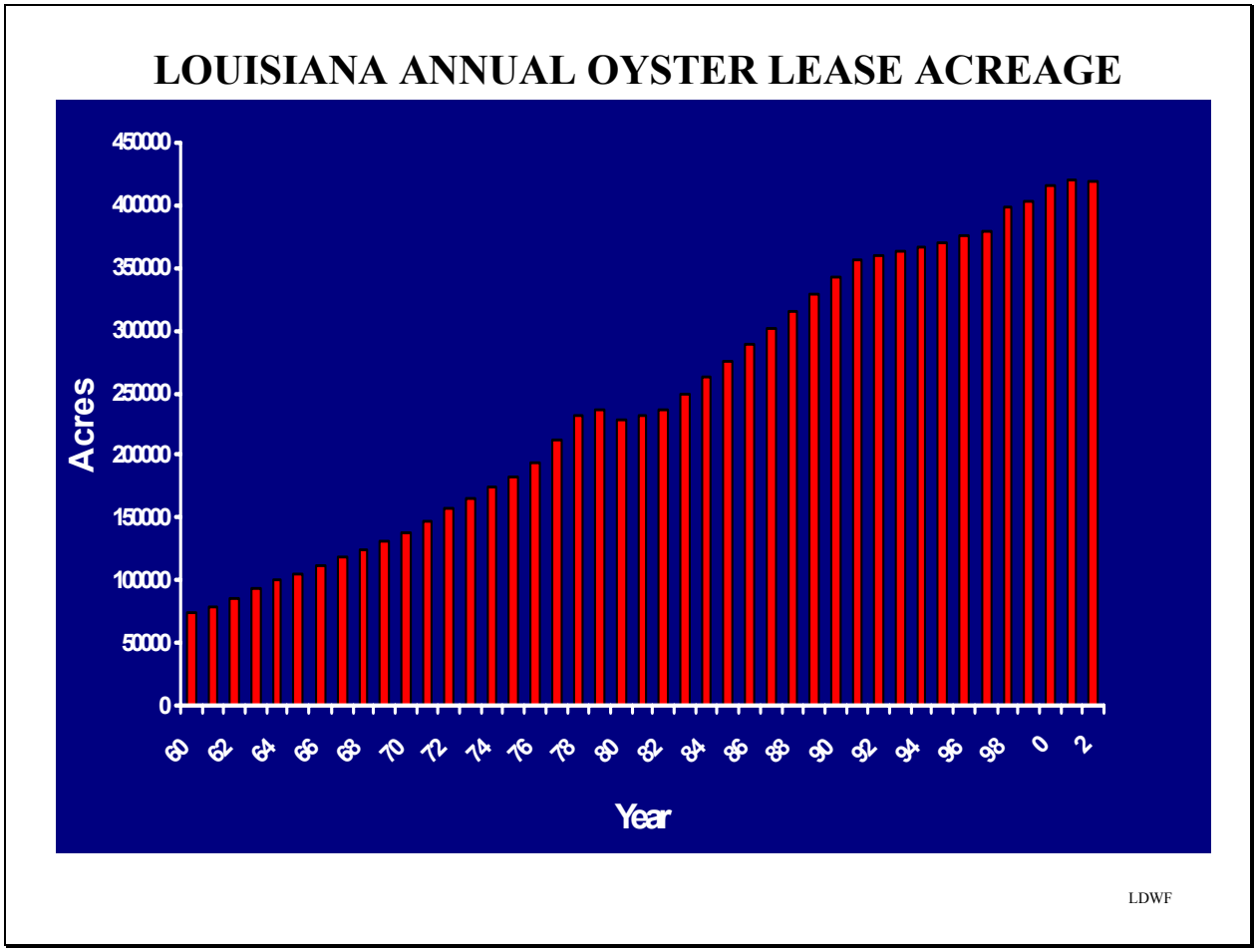
Slide 74


MS Oyster Harvest 1990 - 2003
(Sacks By FY – With 5 Year Average Trendline)
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
'90
'91
'92
'93
'94
'95
'96
'97
'98
'99
'00
'01
'02
'03

Slide 75

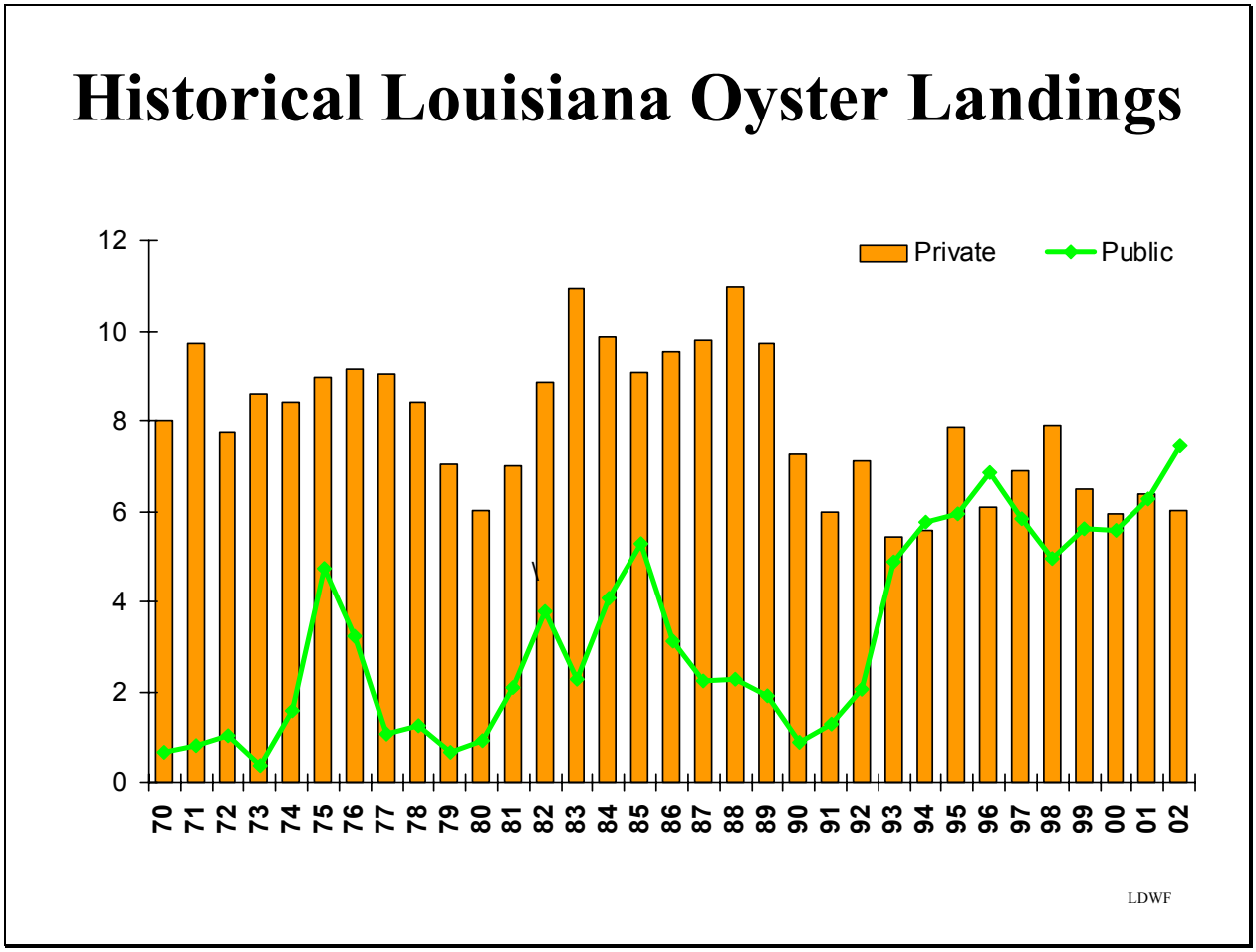

Lake Borgne
Primary Seed Grounds
Calcasieu Lake
Sabine Lake
Lake Chien
Bay Gardene
Lake Felicity
Lake Mechant
Hackberry Bay
Vermilion Bay
Bay Junop
Deep Lake
Barataria Bay
Sister Lake
Lake Tambour
Louisiana Public Oyster Areas
LDWF

Slide 76



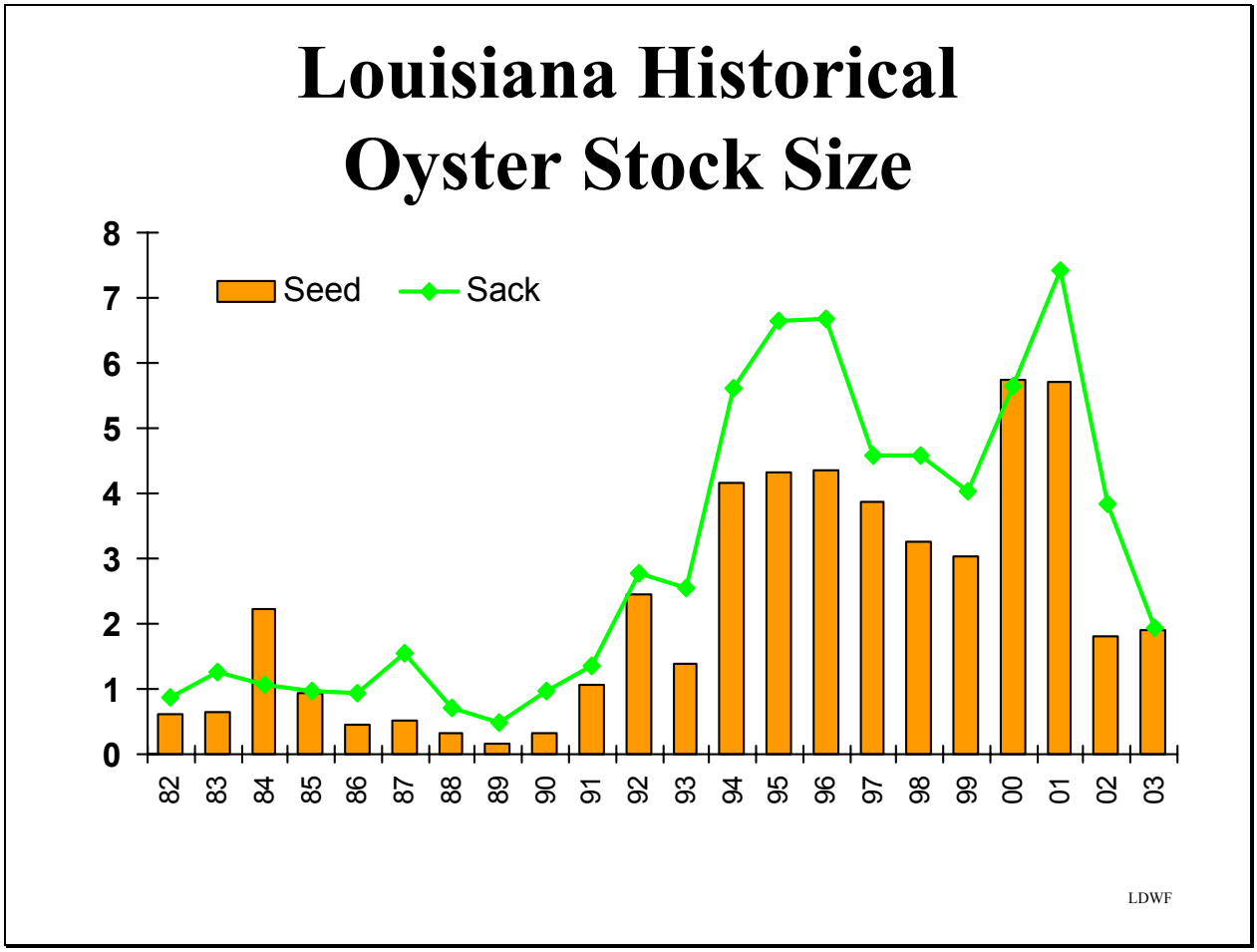
Is there a trend here?

Slide 77



Annual fluctuations are expected due to environmental changes.

Slide 78


Louisiana Historical
Oyster Stock Size
Seed
Sack
8
7
6
5
4
3
2
1
0
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
00
01
02
03
LDWF

Slide 79

Patrol/Enforcement

Patrol/Enforcement
Responsible for the enforcement of laws pertaining to oysters including:
- Size limits
- Daily bag limits
- Closed areas
- Seasons
- Tagging
- Transport
- Gear
- And many more

Without proper enforcement, all the other management efforts are largely ineffective.

Slide 80

Outside Agencies Involved

Regional Agencies

- **University of Southern Mississippi's Institute for Marine Science**
- **Mississippi State University**
- **Jackson State University**
- **Nicholls State University**
- **Mississippi Department of Environmental Quality**
- **Mississippi State Department of Health**
- **Mississippi Department of Wildlife, Fisheries and Parks**
- **Gulf Regional Planning Commission**
- **Marine resource agencies of other states**

Federal Agencies

- **U. S. Food and Drug Administration**
- **U. S. Geological Survey**
- **U. S. Fish and Wildlife Service**
- **U. S. NOAA\National Marine Fisheries Service**

This is an incomplete list of local, state and federal agencies, universities and other entities involved in some way with the management of oysters in Mississippi.

Slide 81

Outside Agencies Involved
(Continued)

- **U. S. Environmental Protection Agency**
- **U. S. Army Corps of Engineers**
- **U. S. Naval Oceanographic Office**
- **U. S. Coast Guard**
- **U. S. Weather Service**

Other Entities

- **Interstate Shellfish Sanitation Conference**
- **Gulf States Marine Fisheries Commission**
- **Mississippi Oyster Processors Association**
- **Gulf and South Atlantic States Shellfish Conference**
- **Louisiana Oyster Task Force**
- **Louisiana Oyster Industry Council**
- **Harrison County Office of Civil Defense**

This is an incomplete list of local, state and federal agencies, universities and other entities involved in some way with the management of oysters in Mississippi.

Slide 82

Harvest

Slide 83

Harvesting Oysters

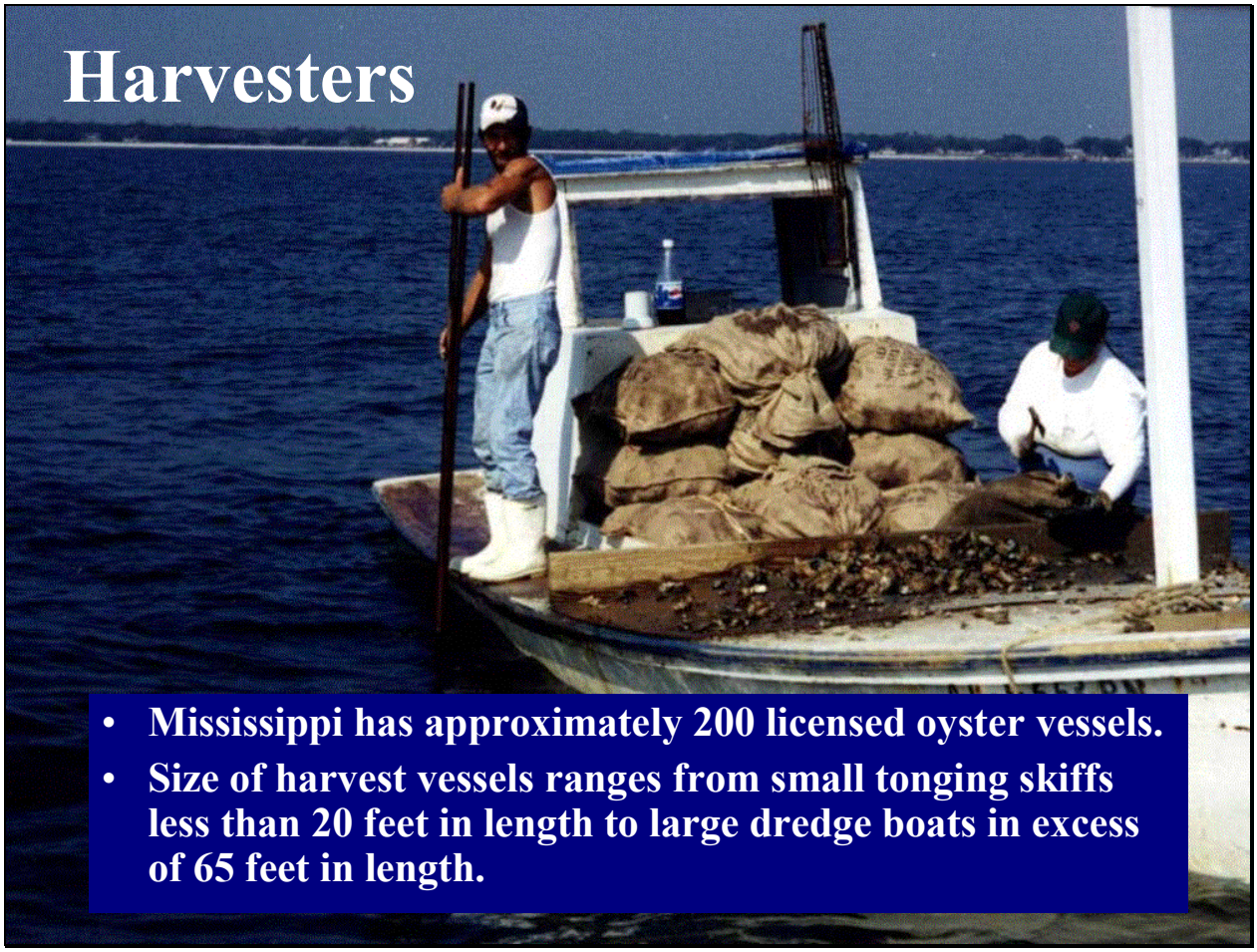
Oysters are harvested from the bottom with tongs or dredges. Oysters are ready for harvest in from 1 to 5 years depending on environmental conditions.

Harvesting Oysters

Oyster harvesters must follow all regulations pertaining to the harvest of oysters set by the state agency regulating the resource and the growing area classification. All states require licenses for commercial harvesters and regulate the type of gear that may be used. Seasons are usually set, and some areas may be closed suddenly do to conditions that may affect the safety of the oysters. This is usually done as a result of a management plan criteria for that area being exceeded (e.g. specified excessive rainfall at a certain location, a particular river gauge exceeding a certain level, tropical storms, hurricanes or a hazardous chemical spill).

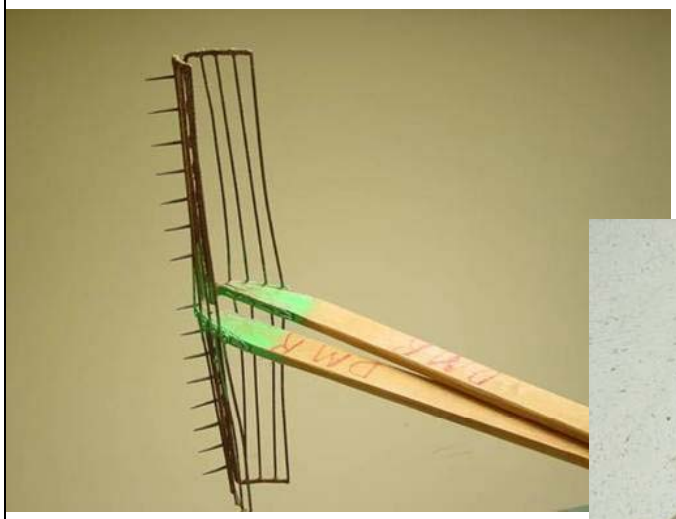
Oyster harvesters, by the nature of their work, must be rugged individuals, capable of braving harsh sea and weather conditions, handling heavy equipment and sacks of oysters. Sometimes, harvesters must cope with the reality of extended area closures, lack of available oysters and low prices.

Slide 84


Harvesters
• Mississippi has approximately 200 licensed oyster vessels.
• Size of harvest vessels ranges from small tonging skiffs less than 20 feet in length to large dredge boats in excess of 65 feet in length.

Slide 85

Oyster Dredge and Tongs



Oyster Tongs

Oyster Dredge

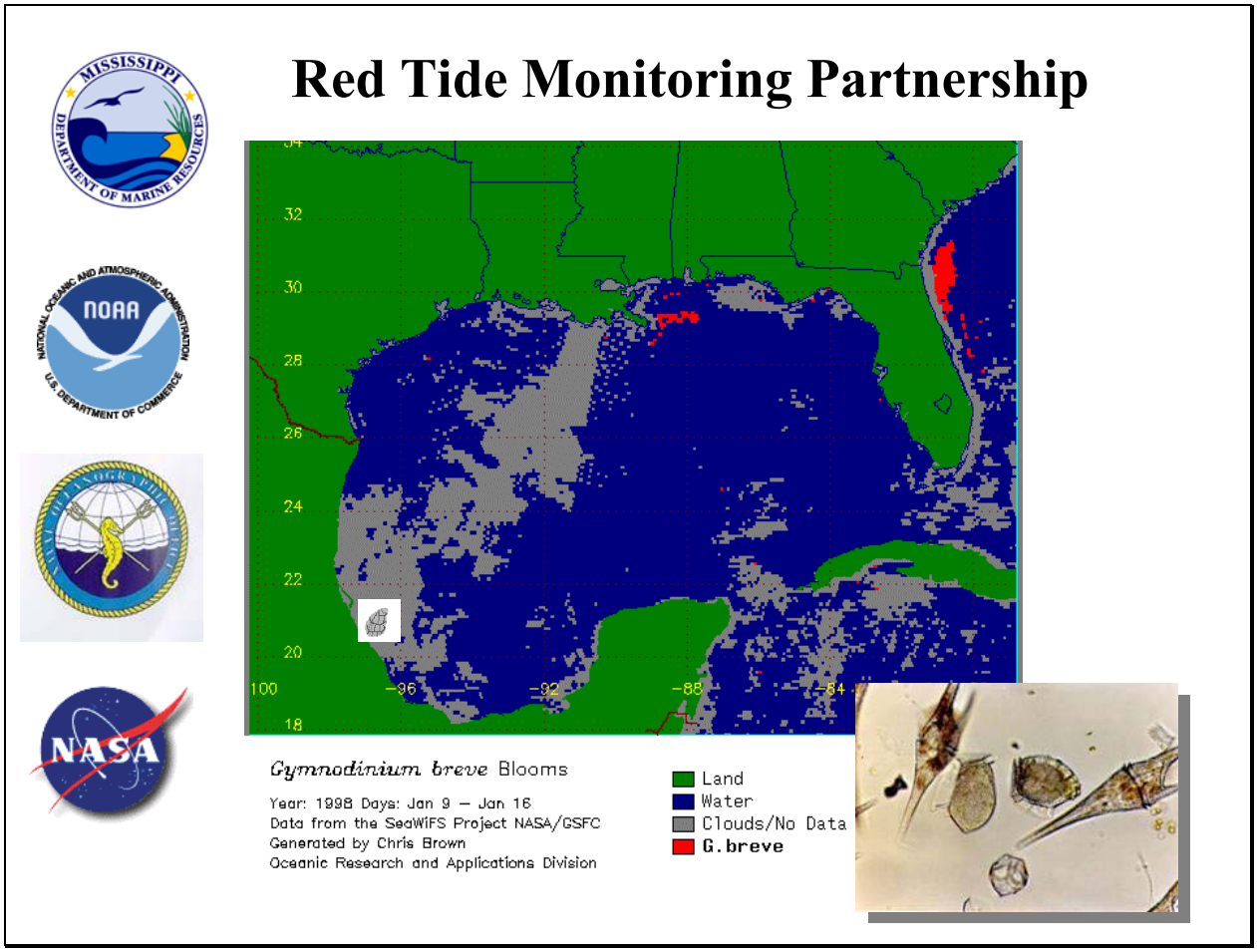
Oyster Harvest Gear
Oyster Tongs
Oyster tongs are a specialized set of rakes that function much like a set of salad tongs you may have at home. The long handles (10 feet and longer) are joined together at a pivot point a few feet above the rakes. The tongs are worked by standing on the side of the boat over the reef, raking the oysters into a small pile, then bringing the oysters up to the boat, hand-over-hand. Sound like tough work? You bet!

Oyster Dredge
Oyster dredges are another type of specialized rake, with the addition of a bag to hold the oysters once they have been dredged (raked) up. Dredges are attached to a chain or cable connected to a powerful winch on the boat. They are usually deployed off the side of the boat. After pulling the dredge on the oyster bottom, it is "hauled" to the surface, hopefully full of oysters. A commercial dredge full of oysters may weigh several hundred pounds.
Once the oysters are on board the vessel, the oysters must be culled (clusters broken up and small oysters and shell returned to the water). This too can be hard work. The small oysters returned to the water will be next years oysters, and the shell will hopefully serve as cultch material for oyster larvae to attach.

Slide 86

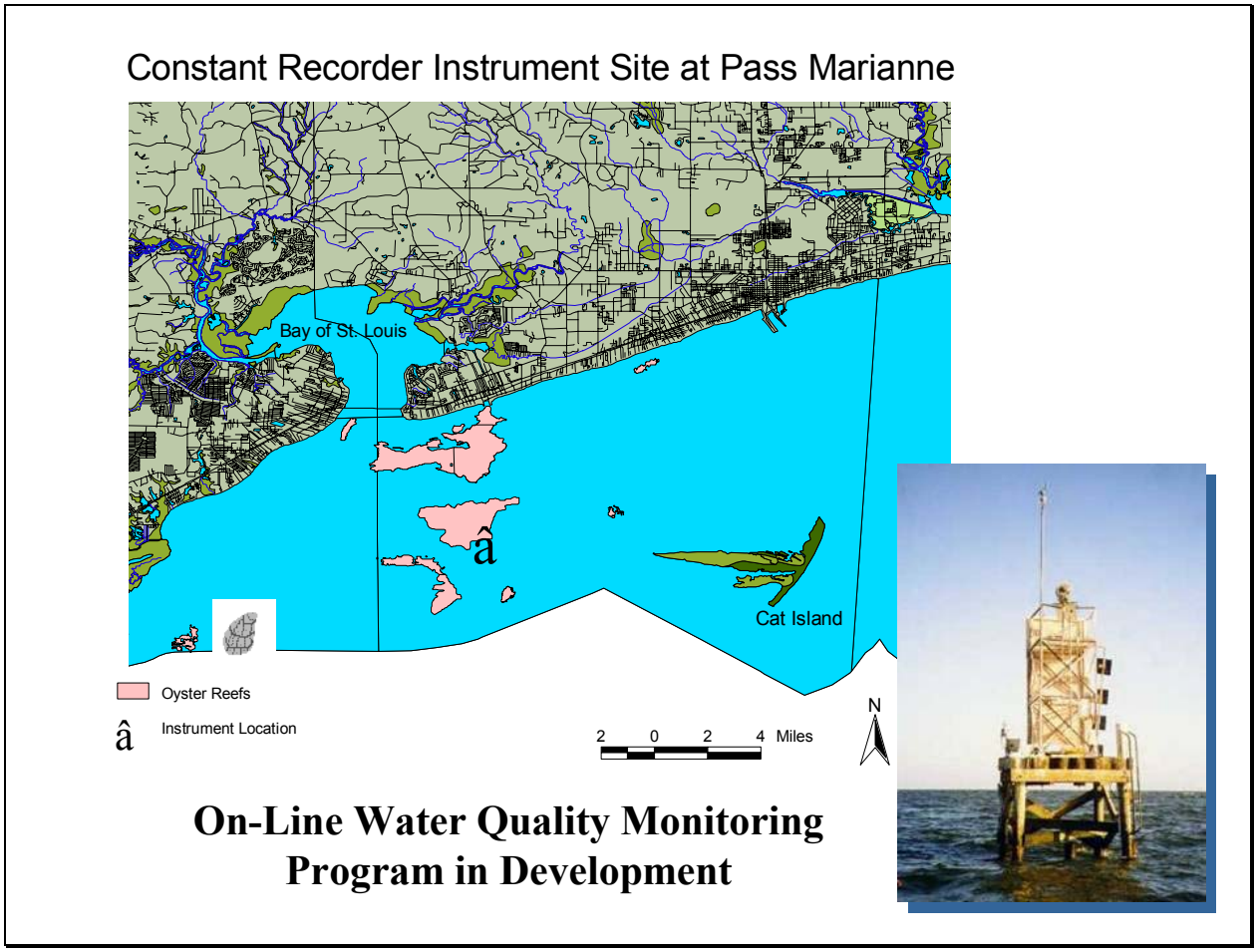
Technologies
New technologies are constantly being developed, while new uses are being found for existing technologies. Technologies in regards to oysters runs the gamut of emerging post-harvest treatment methods designed to reduce certain pathogen levels, to remote sensing by satellite, to constant recorder instruments collecting environmental parameters at the reef and available on the internet, to sidescan sonar used to map the resource, to genetic work used to enhance disease resistance, to improvements in gear efficiencies.

Slide 87



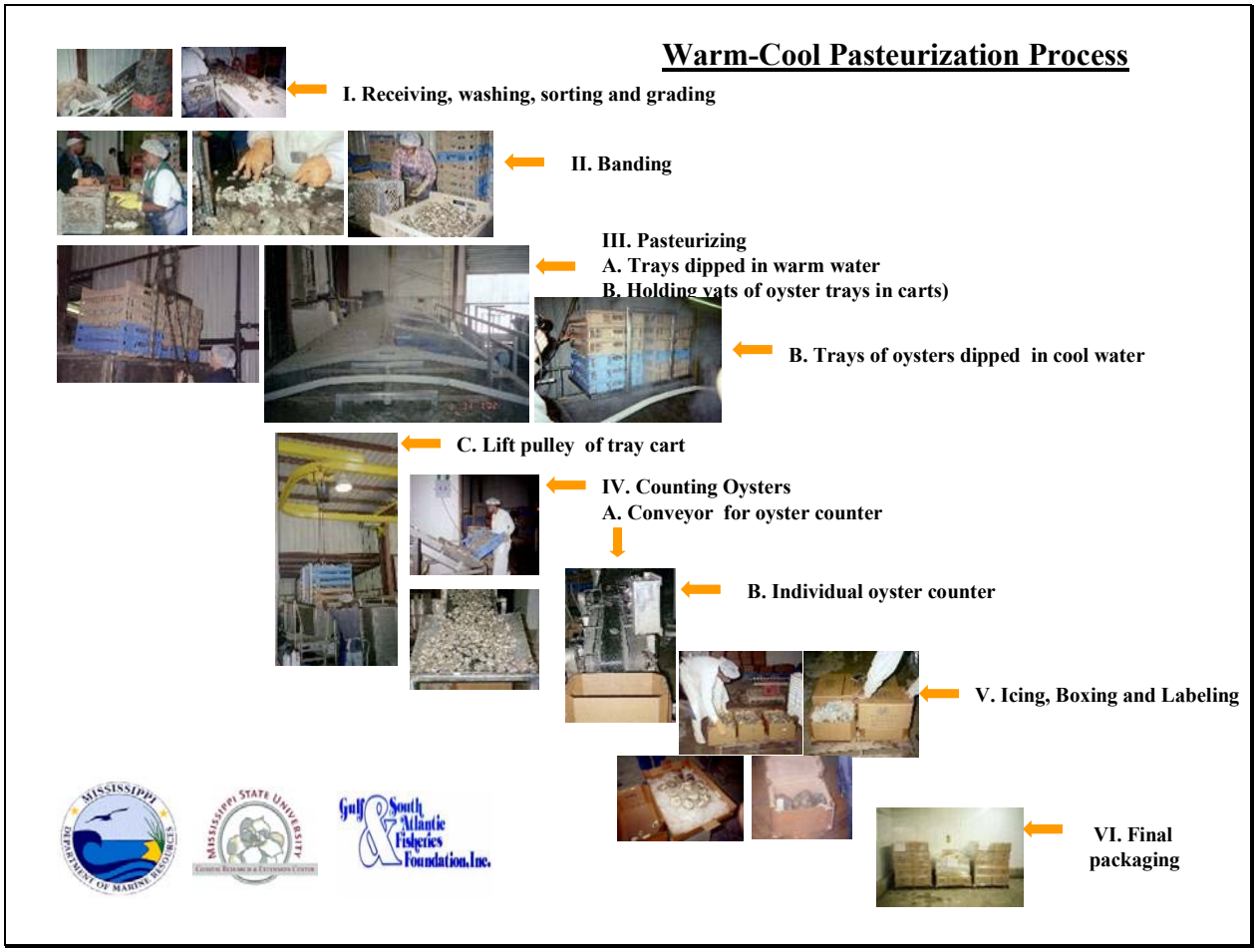
Satellite imaging to determine the location of “red tide” blooms. When toxic red tide blooms occur, oyster harvest may be prohibited in certain areas. Oysters see these toxic organisms as food.

Slide 88



Constant recorders instruments; such as the one pictured here; are great assets to oyster managers for remotely monitoring environmental conditions such as salinity and temperature.

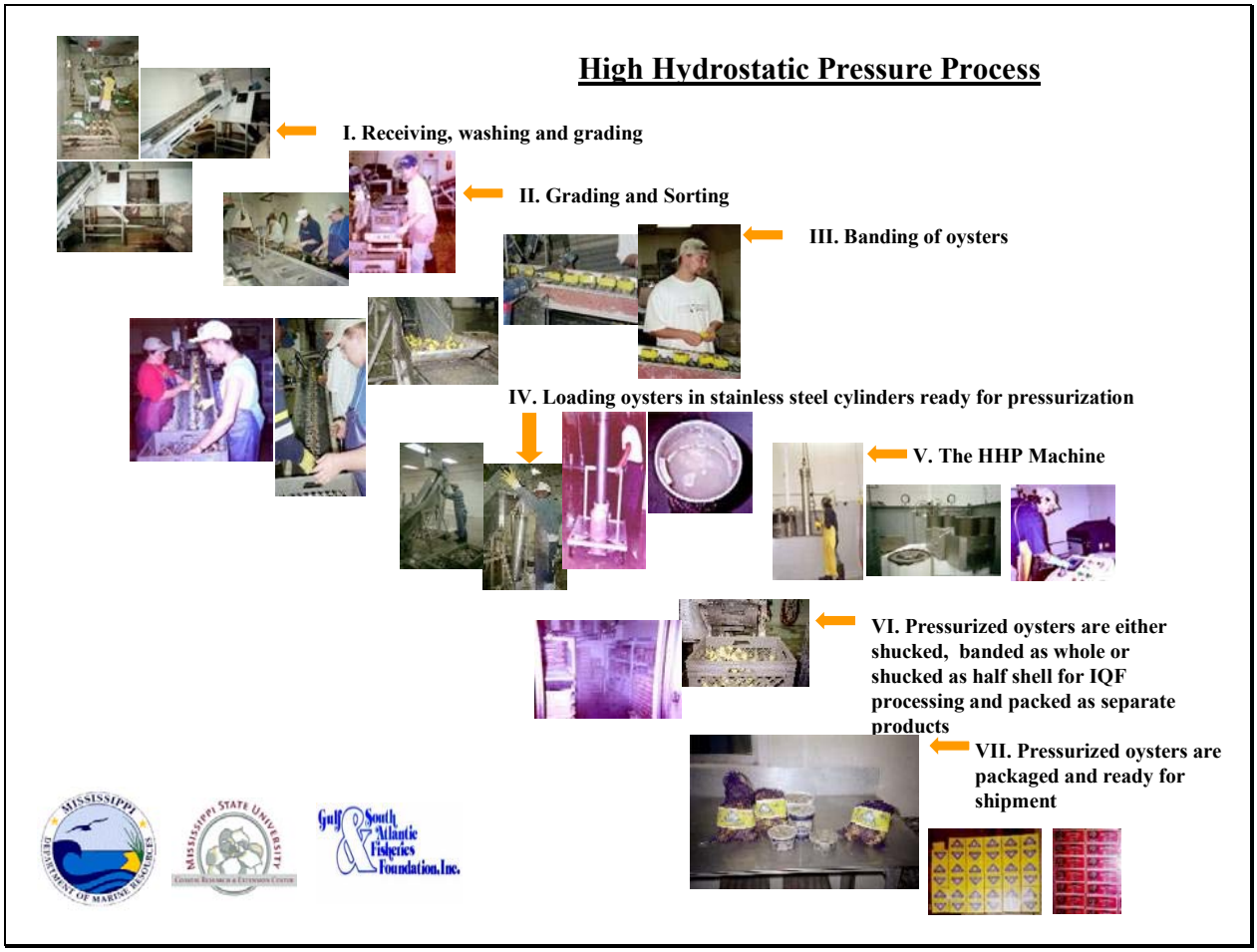
Slide 89



Warm-Cool Pasteurization Process

This is one of the post-harvest treatment (PHT) processes used to reduce *Vibrio vulnificus* to non-detectable levels.

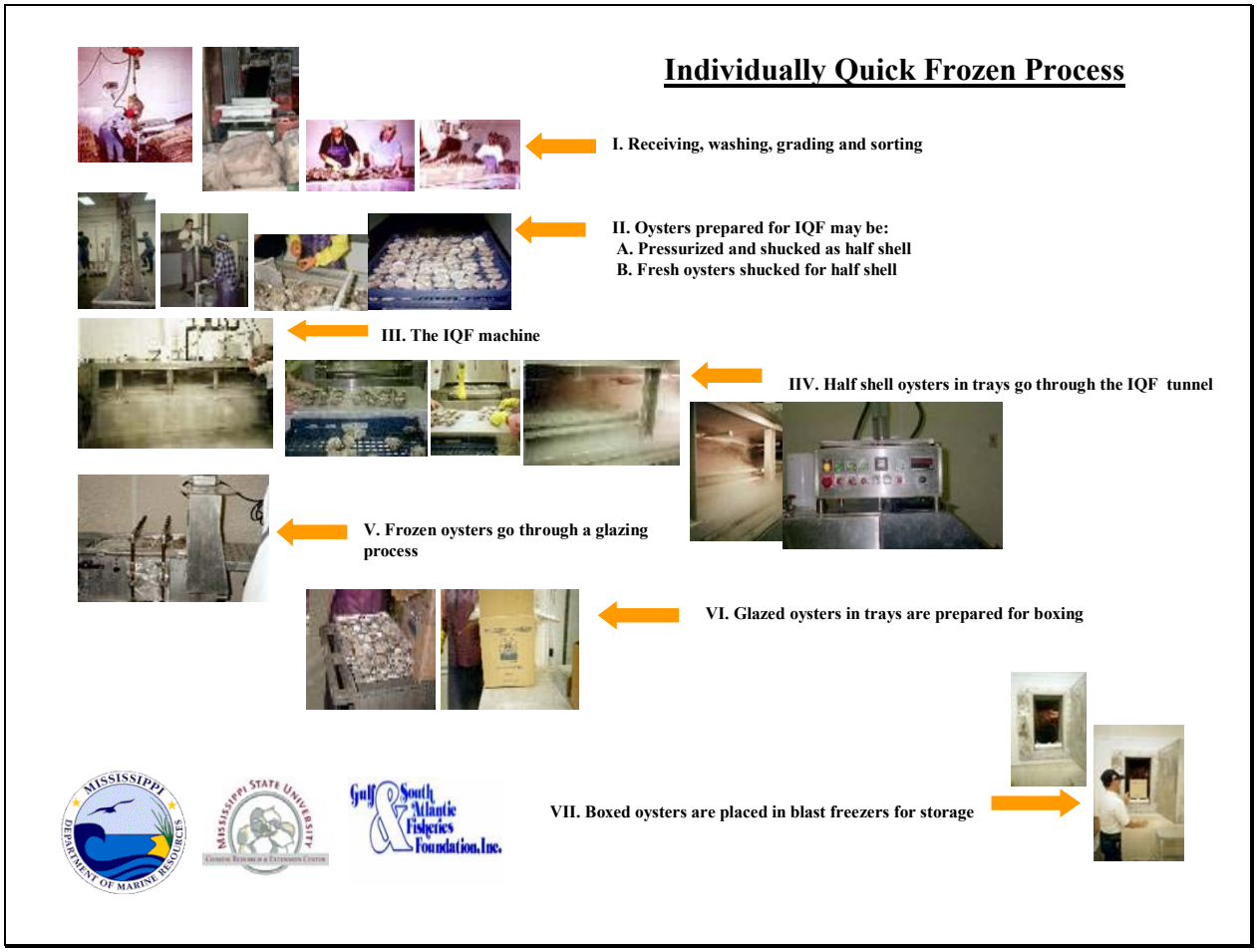
Slide 90



High Hydrostatic Pressure Process

This is one of the post-harvest treatment (PHT) processes used to reduce *Vibrio vulnificus* to non-detectable levels. This one has the added benefit of separating the oyster meat from the shell.

Slide 91



Individually Quick Frozen Process
This is one of the post-harvest treatment (PHT) processes used to reduce *Vibrio vulnificus* to non-detectable levels.

Slide 92

Oyster Aquaculture

- Hatchery Production
- Field Growout

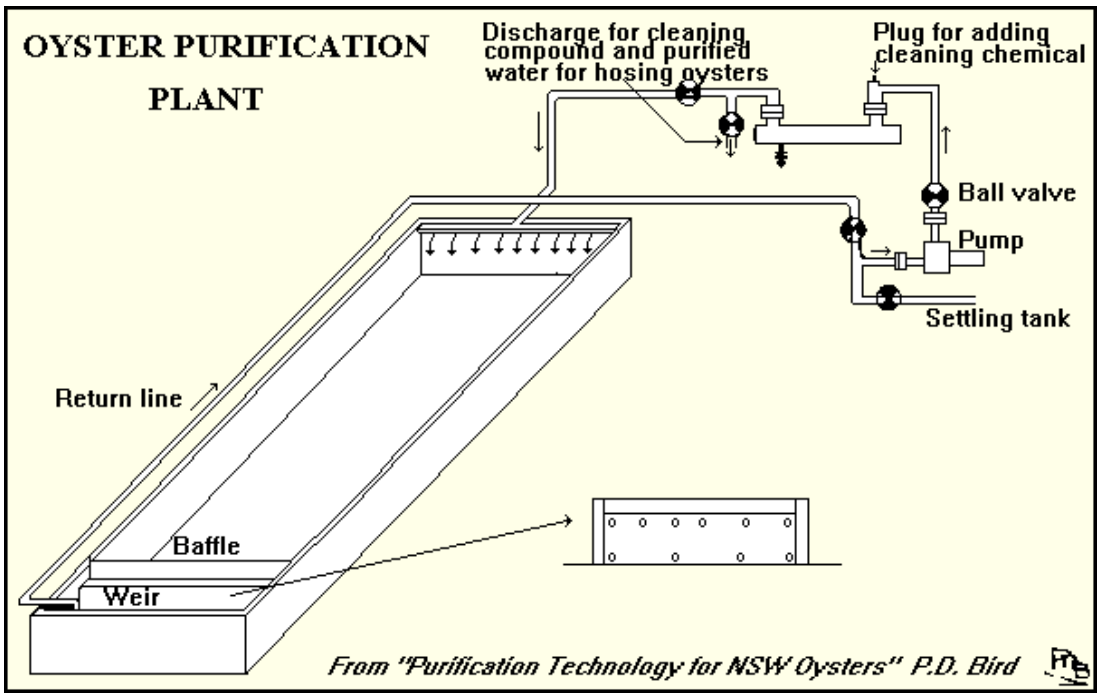





If natural supplies diminish, oyster aquaculture may be one alternative to keep up with consumer demands. Diploid or polyploid oysters may be especially useful in aquaculture operation because no energy is expended by the oyster in producing gametes. These oysters would be “fat” year-round.

Slide 93

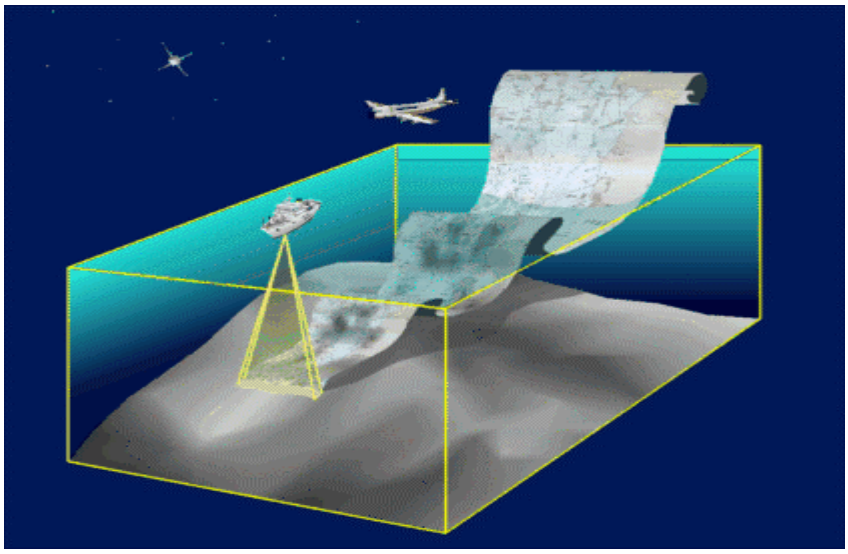
Purging or Depuration



Purging or Depuration
Oysters contaminated by bacteria and viruses harmful to the consumers can be purged by moving them to clean water in the ocean or on land. This allows the utilization of oysters from restricted areas. This is one type of purification or depuration process that could be used on land. The depuration process is highly regulated.

Slide 94

Sidescan Sonar



Sidescan Sonar

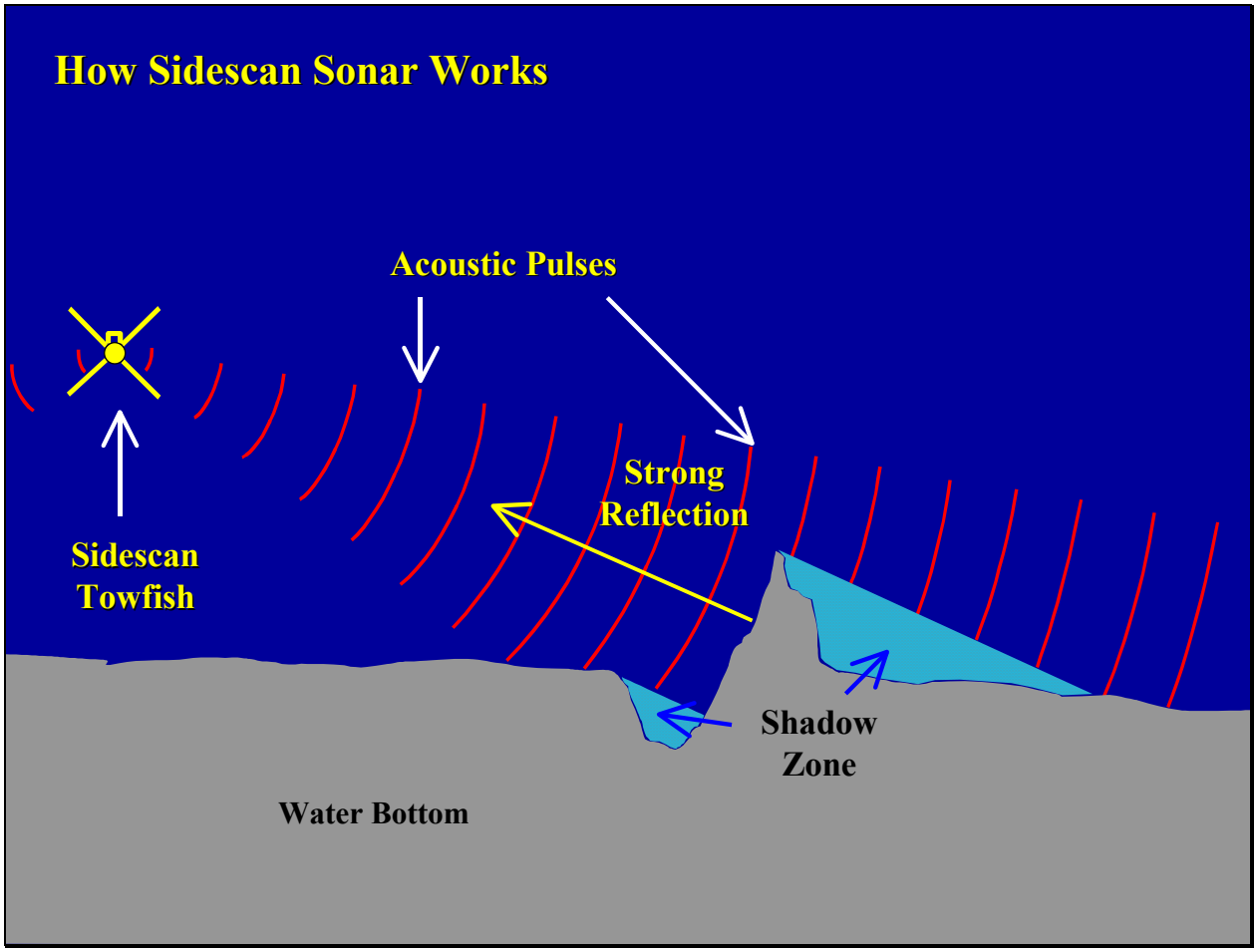
Sidescan sonar is used to help “see” what is on the waterbottom, including oyster reefs.

Slide 95

Side-Scan Equipment and Software

Top Left: EdgeTech 272-TD Towfish on deck.
Top Right: EdgeTech 560 Sonar with EdgeTech operating software.
Bottom Left: Panasonic Toughbook Computer with NobelTec Visual Series nautical charting software interfaced with a Garmin 225 GPS.
Bottom Right: EdgeTech 272-TD Towfish being deployed.

Slide 96



How Sidescan Sonar Works

The sidescan towfish is towed behind the boat where it emits an acoustical pulse.
The acoustical pulse travels at the speed of sound in water, until it meets the bottom or other obstruction.
The acoustical pulse is reflected by the bottom or obstruction back to the sidescan towfish where it is detected.
This information is transmitted through a data cable connected to the sidescan computer onboard the surface vessel.
The sidescan computer processes this signal along with the GPS data, and sends the recorded data to a video screen.
Strong reflections show up as light areas and no or weak reflections show up as dark areas.

Slide 97

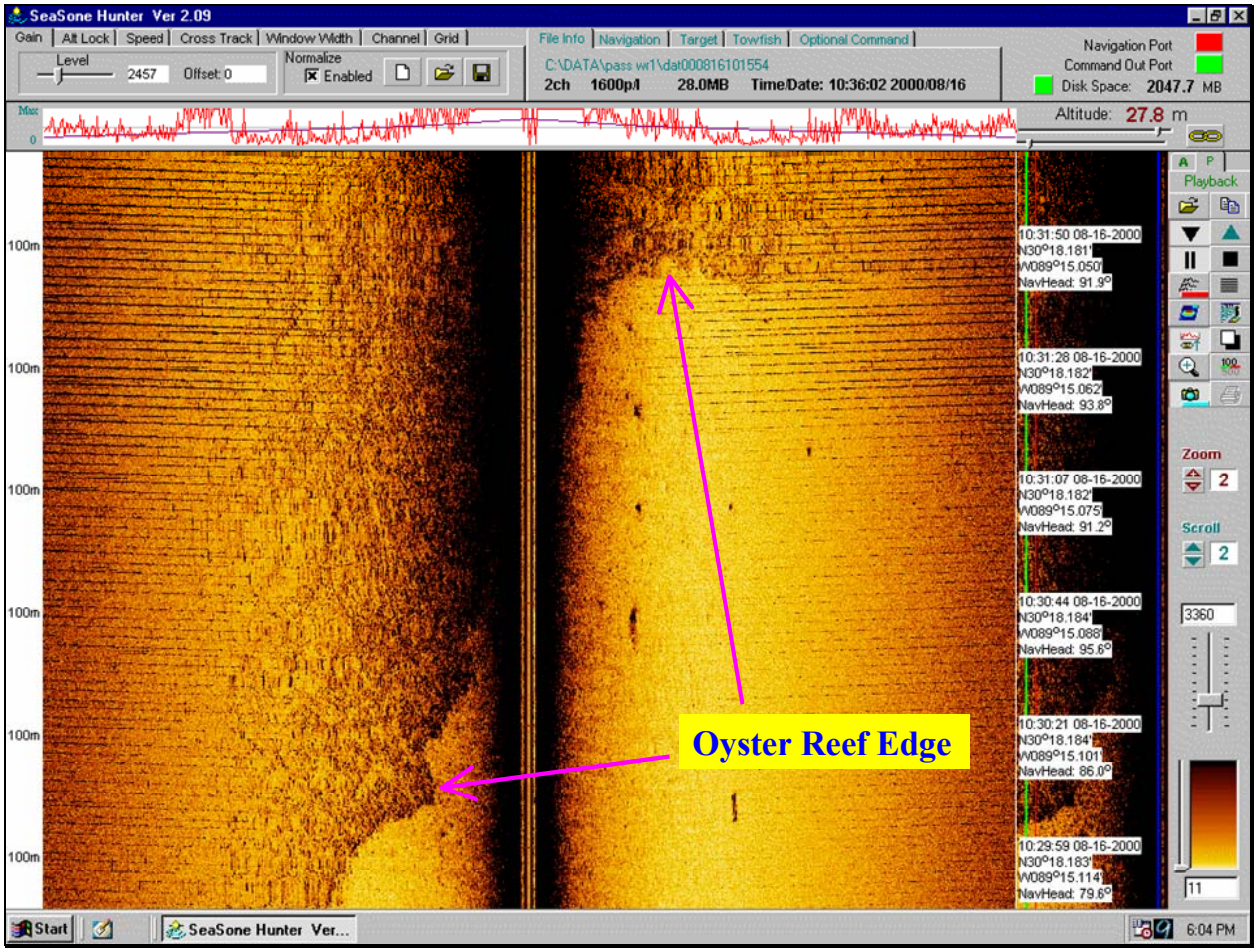
Sidescan Objectives
Shellfish Program

- **Obtain accurate coordinates of oyster reefs.**
- **Identify areas for shell planting.**
- **Assess the damage from barge groundings.**

Sidescan Benefits

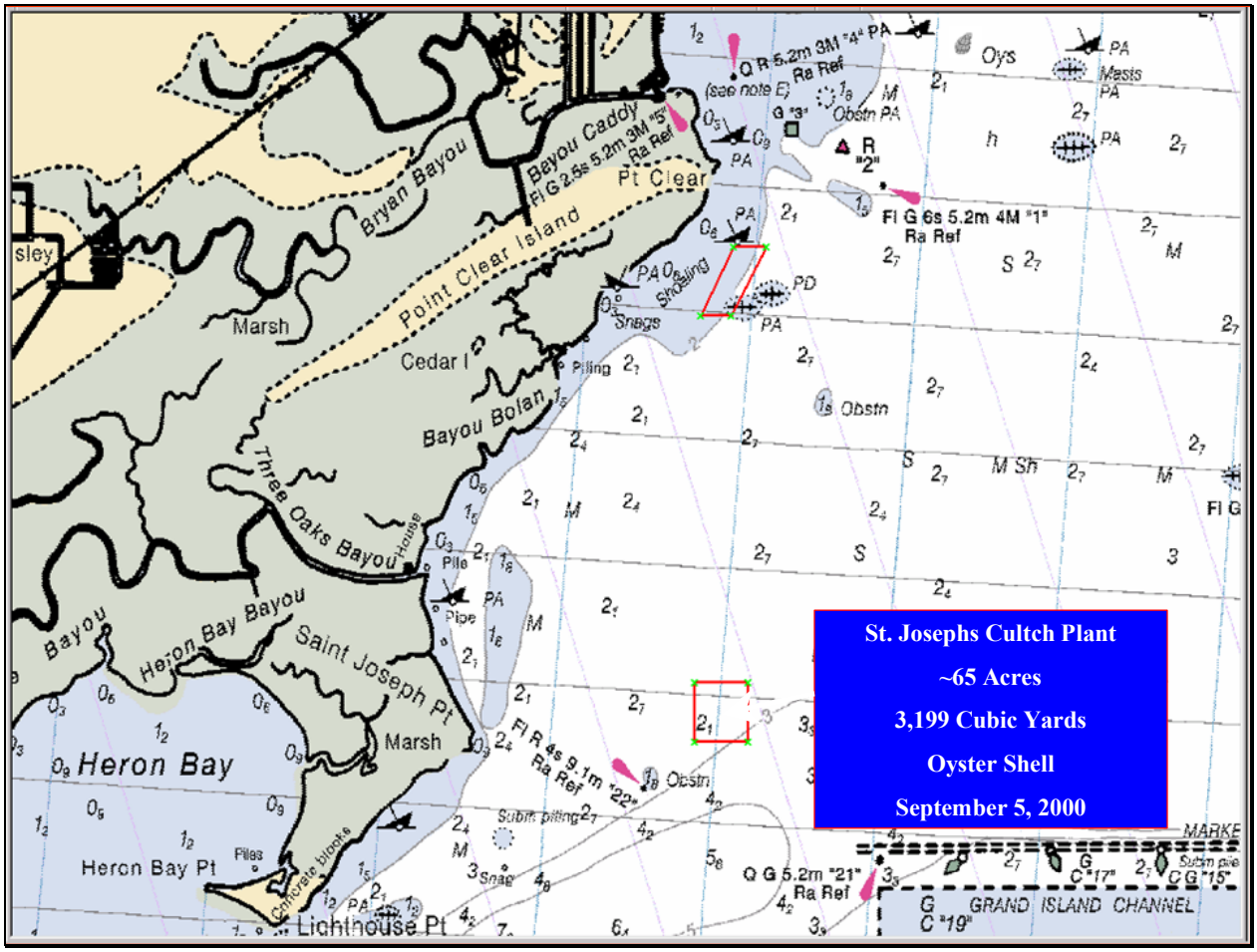
Determine orientation of cultch material and percentage of bottom coverage.
Reef progress or deterioration can be evaluated over time.
Creates a permanent record to assess damages after vessel groundings and major weather events.
Evaluates various cultch planting techniques to maximize area coverage.
Documents whether a contractor has fulfilled their obligation.
Records accurate GPS coordinates.
Surveys large areas in little time.
Calculates footprint or area impacted.

Slide 98



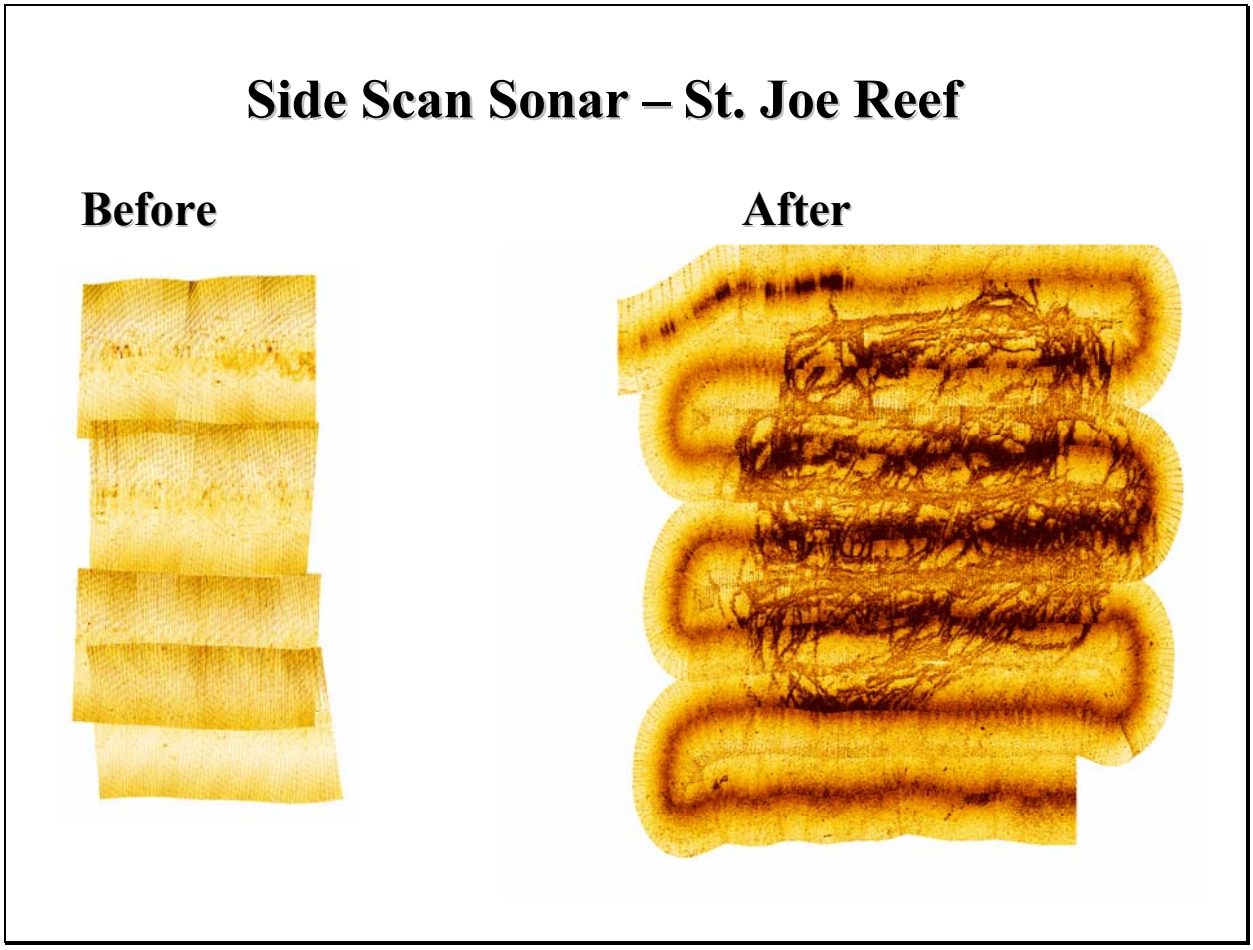
Actual sidescan image clearly showing the edge of an oyster reef.

Slide 99



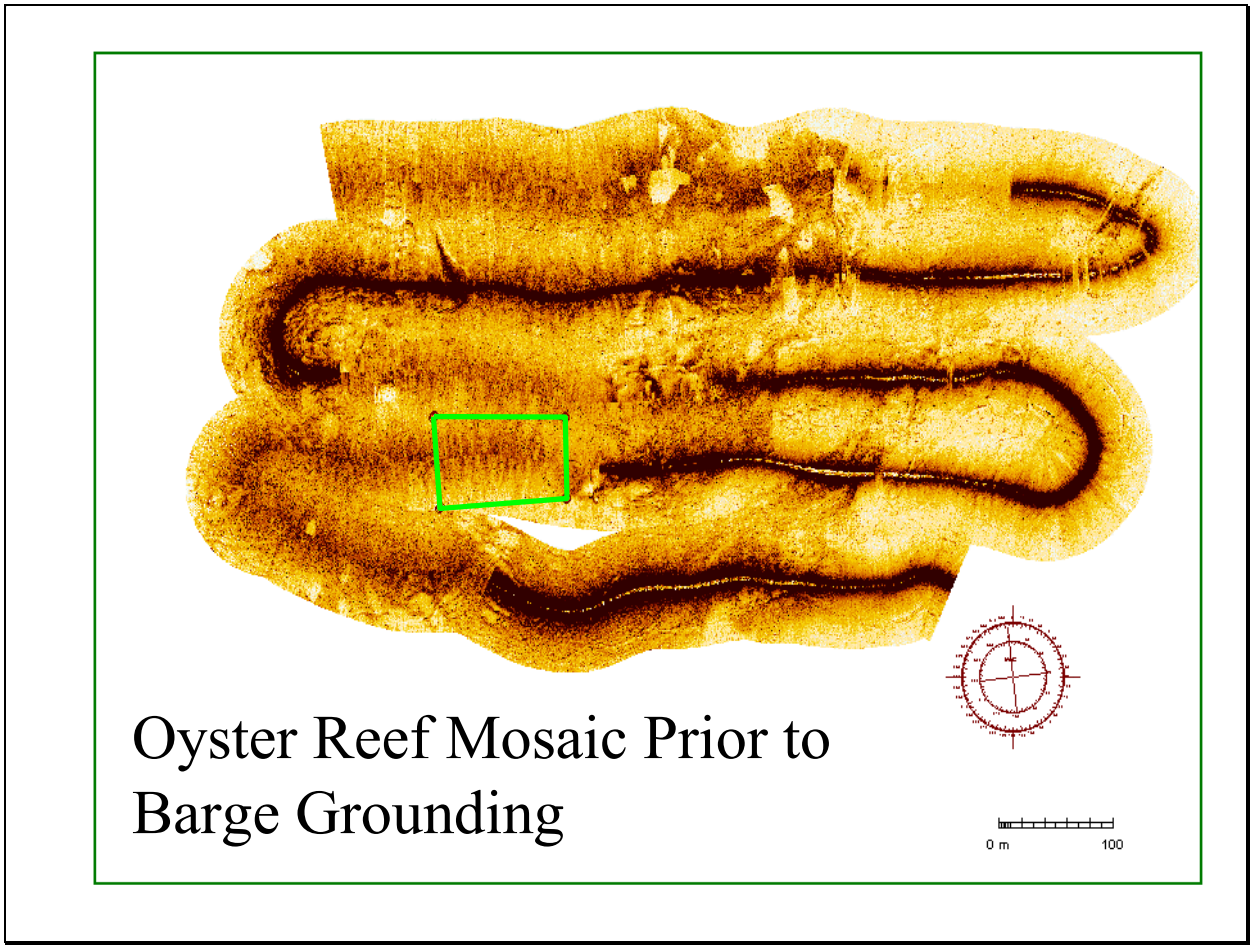
A proposed 65 acre oyster cultch plant site located in the western Mississippi Sound.

Slide 100



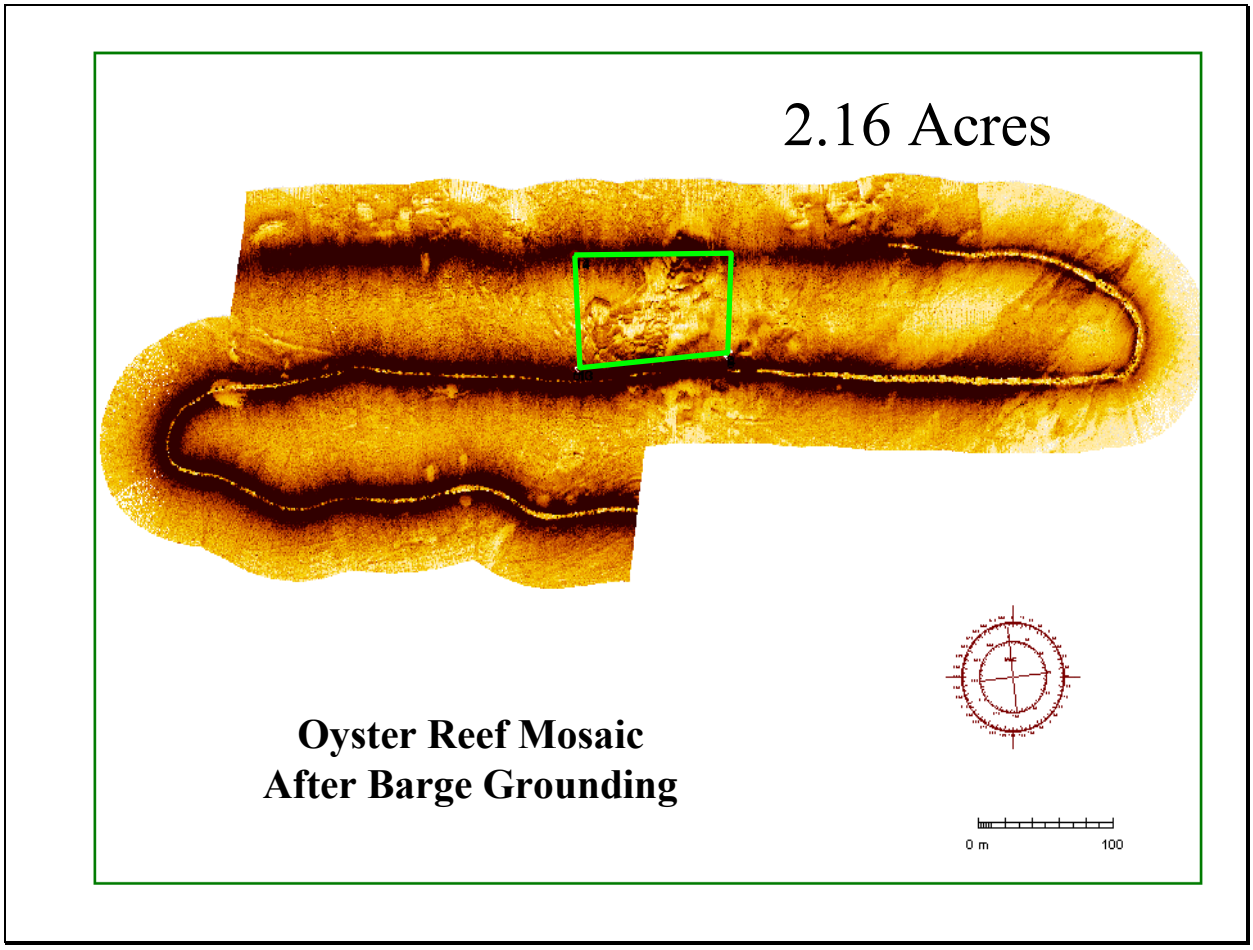
The same 65 acre site viewed by sidescan sonar before and after oyster shell cultch deployment. Note how the movement of the shell barges can seen from the deposition of oyster shell in the "After" image. Follow-up sidescans of this are planned to track the growth of the reef over time.

Slide 101



The reef area was sidescanned for resource purposes.

Slide 102



After a barge ran aground in the same area, a follow-up sidescan was done. Damages to the reef were further assessed by sampling in the field. After being confronted with this evidence, the barge company reimbursed the state for these damages to the reef. Such evidence is difficult to refute.

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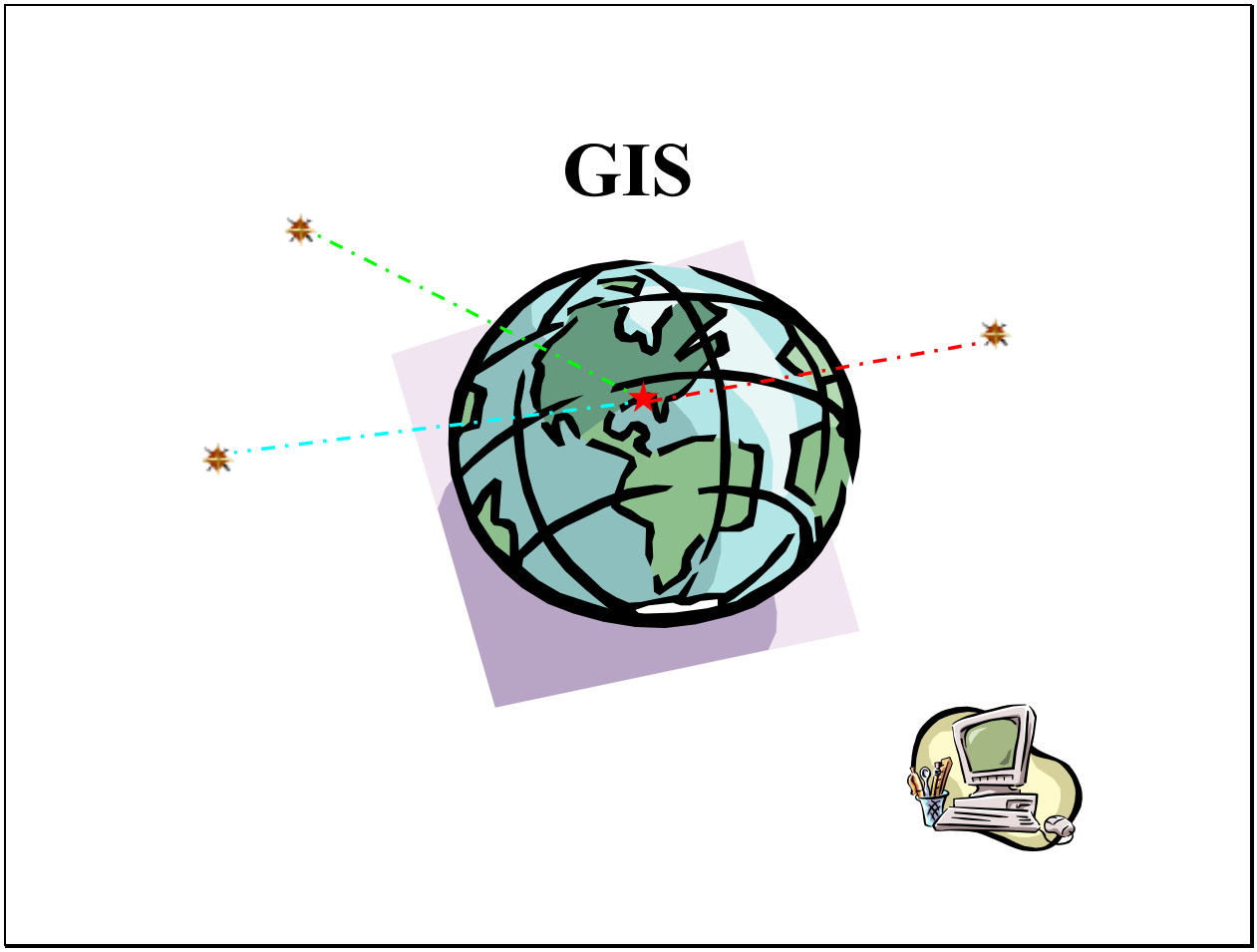
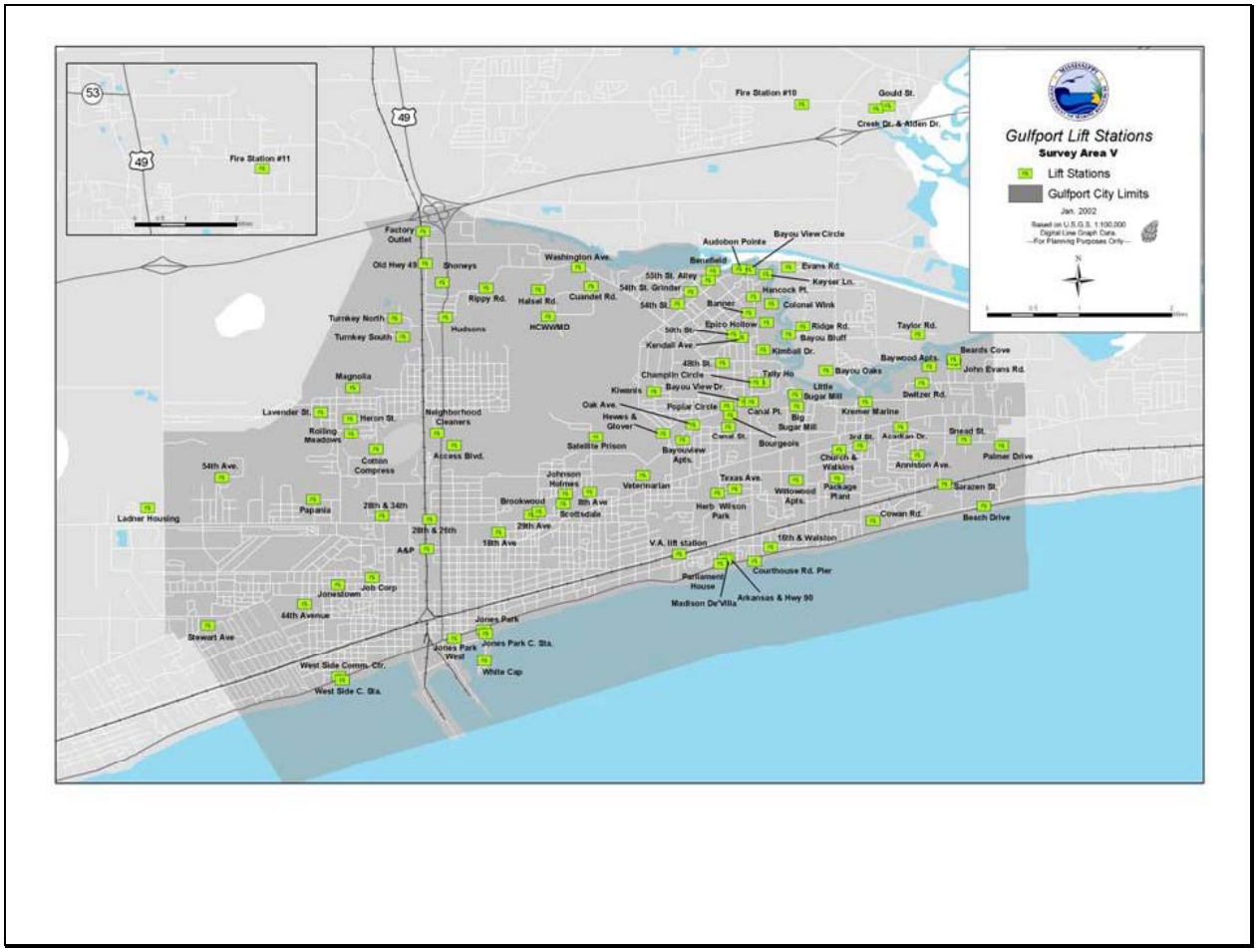


GIS

GIS or Global Information Systems are used to better manage oyster resources. New applications for the use of GIS in the management of oysters are being developed constantly. Data is collected in the field using GPS (Global Positioning Systems) and field notes or portable computer. Digital photographs, sidescan images, physical, biological and environmental parameters along with other digital information are often incorporated into the GIS for that particular location. Collected information may then be used to produce a detailed informational map of the area.

GIS are able to provide geo-referenced data the manager, researcher or even the public can use to obtain and maintain vast amounts of information for different locations.

Slide 104



This GIS map of wastewater lift stations is an example of how GIS is being used to manage shellfish growing waters. In this instance, the map is a portion of a sanitary survey required to properly classify the adjacent waters for shellfish harvest.

The use of GIS may be found elsewhere in this presentation depicting sampling stations, oyster reefs,bottom types, area classification and other regulatory lines.

Slide 105

Weather

We are all at the mercy of the weather, and oysters are certainly no exception.
Excessive rainfall can lower salinities to levels unsuitable for oyster growth or survival and may wash pollution from the land into the shellfish waters requiring area closures. Moderate rains are typically good for oysters by helping to maintain salinities within optimal ranges and washing nutrients over the reefs. Drought conditions result in higher salinities over the reefs and usually result in higher disease and predation.

Extremes in temperature may adversely affect survival and growth.

Extreme winds may cause scouring of reefs through wave action.

Shellfish managers typically monitor both short-term and long term weather patterns and modify their management of the resource accordingly.

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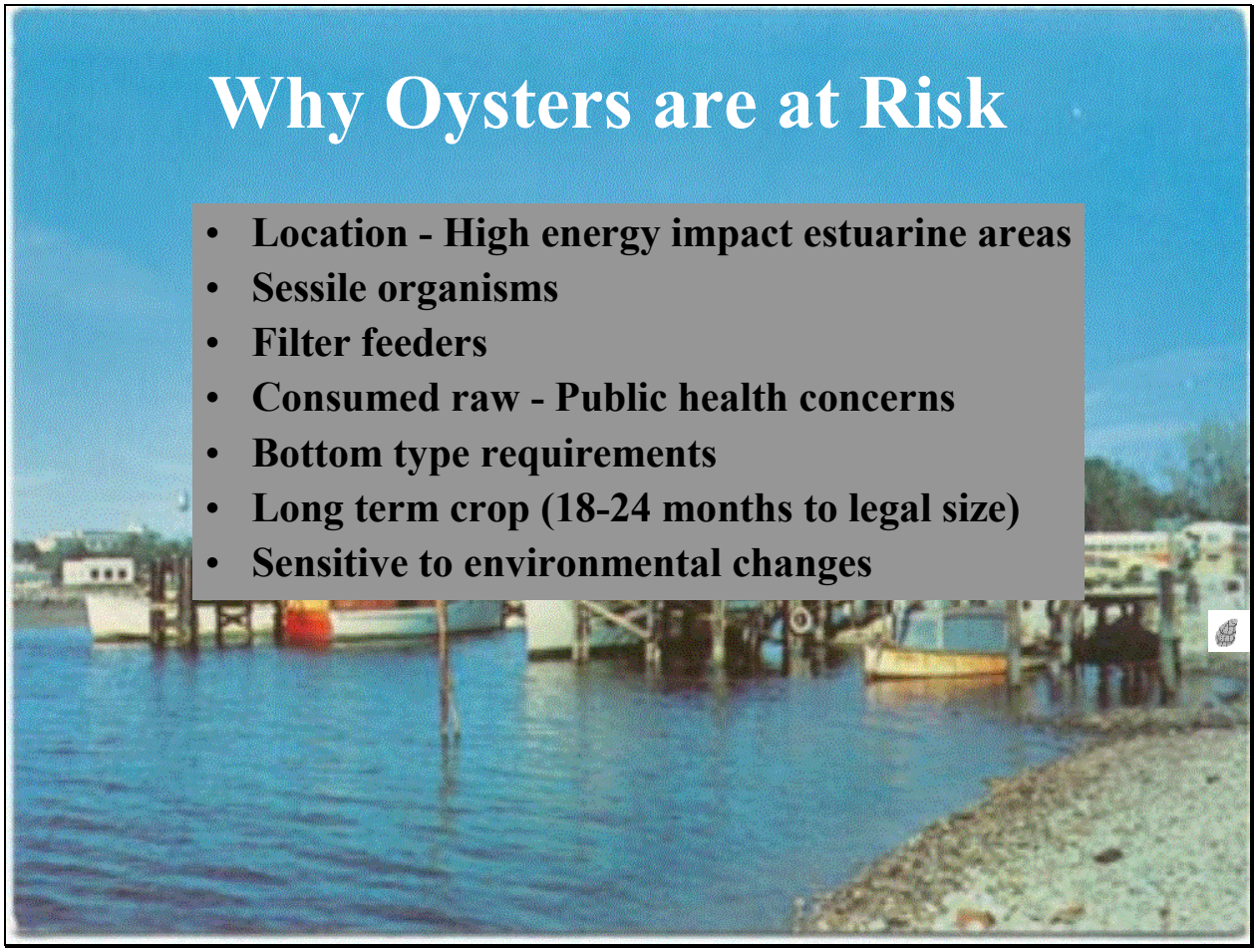
Impacts of Storms and Hurricanes on Oysters
Perhaps the single-most catastrophic event that can occur to the oyster resource.

Slide 107



Storm and Hurricane Effects on Oysters
Scouring of reefs - Physical damage or destruction
Increased pollution - Health and resource threat
Mud and silt deposits - Suffocates and hinders feeding and may cause habitat loss or destruction
Vegetation and debris fouling - Suffocates and hinders feeding
Lowered dissolved oxygen - Suffocates oysters
Lowered salinities due to flooding - Increased mortalities

Slide 108

Negative Effects

- **The large volume and rapid input of fresh rainwater has a greater influence on salinity than saltwater over wash during hurricanes.**
- **It may take years for oysters to fully recover, and it may be a decade or more before the full effects on shellfish populations are seen. Some habitat may be permanently lost.**
- **Hurricanes also cause a loss of stratification of surface and bottom waters resulting in an initial short-term increase and then a long-term decrease in dissolved oxygen concentrations.**
- **Household and industrial chemicals, motor oil, pesticides, building materials and organic debris are among the diverse pollutants that typically end up in coastal waters.**
- **Catastrophic loss of electric power, which can disrupt operations at chemical and industrial facilities may result in discharges that pollute the environment.**
- **Flooding overloads wastewater treatment facilities.**

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Positive Effects

- Water churned up by a hurricane may help refurbish the fisheries.
- Nutrients tied up in the water bottom can be stirred up and redistributed back into the aquatic system, and what is initially a disaster may have beneficial long-term effects.
- “Nature tends to heal itself.”
- Some scouring exposes clean surfaces for oyster larvae to attach.
- Some scouring may help remove built up silt, mud and pseudofeces from oyster reefs.
- Oysters may be induced to spawn.

Slide 110

Vibrio vulnificus

Consumer Information Message

As in the case with consuming other raw animal protein products, there is a risk associated with consuming raw oysters, clams, and mussels. If you suffer from chronic illness of the liver, stomach, or blood, or have immune disorders, do not eat these products raw.

What is *Vibrio vulnificus*?

You may have seen this consumer information message similar to this one on a tag attached to a sack of oysters or posted or on menus in restaurants that sell raw oysters.

Vibrio vulnificus is a gram-negative bacterium and is considered the most lethal of the *Vibrios* inhabiting brackish and salt water. This bacterium is NOT the result of bacteriological or chemical pollution of marine waters, but occurs naturally in warm, coastal areas, such as the Gulf of Mexico. *V. vulnificus* is found in higher concentration from April through October when coastal waters are warm. *V. vulnificus* does NOT change the appearance, taste, or odor of oysters of clams. Proper cooking will kill the *Vibrio vulnificus* bacterium.
Public education of those “at-risk” individuals is very important.

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Recipes

Nutrition and Cooking

Oysters are good to eat all year long, but are in best condition and most tasty in the winter and early spring. Raw oysters have a protein content of about 9 percent and a fat content of less than 2 percent. One-half pound of raw oysters contains about 150 calories. The cholesterol content of oysters is 50 milligrams/100 grams of meat, and the sodium content is 109 milligrams/100 grams. Oysters are also very high in iron content.
Once an oyster has been removed from its' shell (shucked), the meat can be completely consumed. It is one of the few foods that can be eaten raw. Oysters harvested from approved waters, packed under sanitary conditions, and properly refrigerated are usually safe for raw consumption by healthy individuals. Cooking oysters to an internal temperature of 140° F or greater for 4-6 minutes destroys the common microorganisms of public health concern.
This coast cuisine can be eaten on the half-shell, fried, smoked, baked, broiled and steamed, and can be found in stew, soup, gumbo, dressing and seafood casseroles and on the menus of most local seafood restaurants. Oysters can be enjoyed in a variety of cooked preparations including steamed, stewed, roasted, baked, broiled, sautéed, poached, and fried. There are countless ways of preparing oysters.

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Tips For Cooking Oysters & Clams In The Shell

Boil live oysters in boiling water for 3 to 5 minutes after shells open. Use small pots to boil or steam oysters. Do not cook too many oysters in the same pot because the ones in the middle may not be fully cooked. Discard any oysters that do not open during cooking. Steam live oysters 4 to 9 minutes in a steamer that is already steaming.

Tips For Cooking Shucked Oysters & Clams

Boil or simmer for at least 3 minutes or until edge curl.
Fry in oil for at least 3 minutes at 375° F.
Broil 3 inches from heat for 3 minutes.
Bake for 10 minutes at 450° F.

What are visible characteristics of quality oysters?

Oysters in the shell (shellstock) should not gape and should close readily when tapped. If the shell does not close tightly or the oyster meat is dry when the shell is open, the product should be discarded. Avoid eating oysters when their shell is broken or damaged. The meat of shucked oysters is usually a creamy tan color, plump, and should smell fresh and mild.

Oysters may be eaten safely during any time of the year. However, oysters are highly perishable and can spoil quickly in the hot summer months if they are not properly refrigerated. Oysters can be kept fresh longer by using today's improved temperature controls and distribution capabilities.

Shellstock should be washed to remove excess debris before storage in well-ventilated refrigerated areas. The temperature of refrigeration units where oysters are stored should be between 34° F and 45° F. Shellstock should never be stored in airtight containers. Shucked oysters also require refrigeration, and consumers should closely adhere to the recommended expiration date on containers. Raw and cooked oysters should be handled separately to avoid possible cross contamination. Workspace and utensils should be thoroughly cleaned between preparations.

Slide 113

Recipes

Angels On Horseback

1 jar (12 ounces) fresh oysters, drained ½ teaspoon lemon pepper

2 tablespoons chopped parsley 10 slices bacon, cut in thirds

Place an oyster on each piece of bacon and sprinkle with parsley and lemon pepper. Wrap bacon around oyster and secure with a toothpick. Place oysters on a broiler pan. Broil about 4 inches from source of heat for 8 to 10 minutes or until bacon is crisp. Turn carefully. Broil 4 to 5 minutes longer or until bacon is crisp. Makes approximately 30 hors d'oeuvres.

Oysters may be frozen, but once thawed, the texture of the meat becomes softer and the oysters are generally not suitable for raw consumption. Frozen oysters, however, are quite acceptable when they are cooked. Oysters should be frozen quickly at a temperature of 0° F or lower. Rapid freezing results in smaller ice crystal formation and less tissue damage. Freezer bags and plastic containers with lids are preferred for freezing. Oysters should be frozen immersed in their liquor or water and excess air should be expelled from the containers to provide protection from freezer burn. In storage, frozen oysters should be maintained at 0° F or lower. Oysters should always be thawed in the refrigerator and at least 24 hours should be allowed for thawing. Oysters should never be refrozen.

Although oysters are usually creamy tan, their diet or certain environmental conditions may cause them to take on other colorations. Oysters that have filtered certain microscopic organisms as food may have a reddish or greenish coloration. Pigments from these microorganisms may dissolve in water and are sometimes seen in the liquor. These discolorations are harmless and disappear when the product is cooked. However, a pink discoloration in oysters accompanied by an offensive odor is caused by the presence of yeast. These oysters should be discarded.

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Recipes

Stewed Oysters of the 1700's

Take two dozen oysters, put them in a stewpan with three ounces of bread-crumbs, add the strained liquor from the oysters, a little mace, also pepper to taste, two ounces of butter, and one tablespoonful of vinegar. Boil all together for a short time, but mind the oysters do not harden. Garnish the dish with fried sippets*, and serve very hot.

*small triangular-shaped pieces of toast (or croutons)

Baked Oysters

Cut day-old bread into thin slices, remove crust. Toast lightly in 325-350° F. oven. Butter lightly, and moisten with a little oyster liquor. Place 6 oysters on each slice of toast. Season lightly with salt and cayenne pepper. Dot with butter. Place in 450° F. oven until the edges of the oysters curl. Serve hot.

Nutrition
Ounce for ounce
oysters offer fewer calories and about the same level of cholesterol as white-fleshed fish much lower in fat, cholesterol and calories when compared to poultry.
Nutritionally well-balanced
The National Heart and Lung Institute suggest oysters as an ideal food for inclusion in low-cholesterol diets.
Oysters are an excellent source of vitamins A, B1 (thiamin) B2(riboflavin), B3 (niacin), C (ascorbic acid), and D (calciferol).
Four or five medium size oysters supplies the recommended daily allowance of iron, copper, iodine, magnesium, calcium, zinc, manganese and phosphorus.
But… it depends on the other ingredients in the recipe as to the final caloric content of your dish. You may try substituting margarine for butter, etc.

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Future

Biggest Concerns for the Oyster Industry

- Water quality
- Suitable cultch availability
- User group conflicts
- Low ex-vessel price
- Natural causes (Storms, Red Tides, Droughts, etc.)
- Maintaining fresh water supply to provide ideal salinity regimes
- Predators, disease, competitors (Oyster drills, Dermo, Hooked Mussels)
- Unloading facility availability
- Public health concerns
- Resource abundance
- Education of harvesters (Legal, resource and public health issues)
- Wetland alterations

Future
Overall, the future continues to be bright for oysters. Many of these problems are being addressed on the local, state and federal level. However, some of the concerns are out of the hands of humans. Resource managers will continue to address these issues where possible. New methods of addressing many of these issues will be developed.

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Lagniappe –

A healthy oyster can filter approximately 60 Gallons of water every day!

The Guiness World Record for eating oysters is held by Tommy "Muskrat" Greene of Deale, MD, who ate 288 oysters in 1 minute, 33 seconds. Wow!

Too many for me.

Slide 117

Market

Live

Shucked

Oysters are sold live, fresh and frozen on the half shell and shucked, canned and smoked.

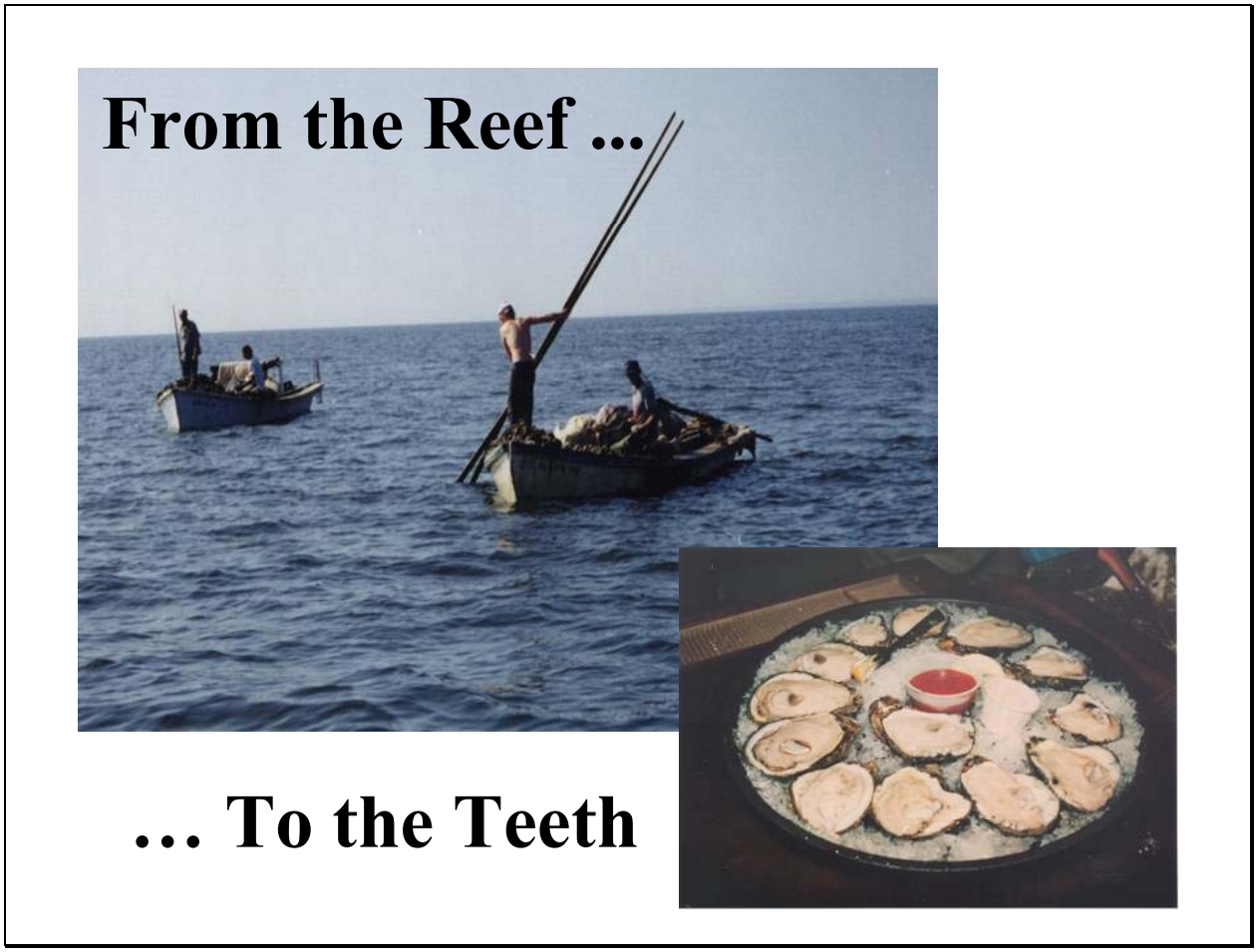
Fresh on half shell

Frozen on half shell

Canned

Anyone hungry?

Slide 118



From the early **history** of Native Americans consuming oysters and forming shell middens that can still be found today; to the **biology** of the life cycle of the oyster, spat to adult, and the affects of changes in salinity can have on oysters; from the **predators** like black drum and oyster drills and **diseases** like DERMO; from the importance of **water quality**; to the necessity of **habitat creation**; from how and why **resource assessments** are conducted; to the **management** of the oyster fishery; how **harvesters** catch oyster with tongs or dredges; to new **technologies** like sidescan sonar and their application; from the effects of **weather** like storms and hurricanes; to the dangers of ***Vibrio*** *vulnificus* to "at-risk" consumers of raw oysters; from a sampling of a few delicious oysters **recipes**; and on to the **future**...
You have reviewed oysters, **From the Reef to the Teeth**.

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Oysters' Contributions Extend Beyond Commercial Harvest *

- Structural Organisms (Huston, 1994)
- Water Processing
- Aquatic Vegetation Restoration (Mann, 2000)
- Biodiversity Conservation
  (Berrigan, 1990; Coen, Luckenbach, and Breitburg, 1998; Brumbaugh, *et al.*, 2000)
- Commercial Fish and Crab Habitat
  (Mann, Burreson, and Baker, 1991)
- Recreational Fisheries (Mertz, 1999)

* slide from Jack Isaacs et al. 2002. The Uses and Values of Louisiana's Oyster Reefs As Recreational Fishing Grounds. Presented at the National Shellfisheries Association annual meeting, Mystic Connecticut.

Want to know more?

Slide 120

Online Resources

- **The Gulf Oyster Project** - http://www.gulfoysters.net/index.html
- **Interstate Shellfish Sanitation Conference** - http://www.issc.org/
- ***Perkinsus marinus* - Oyster Disease of Gulf Coast Oysters** - http://www.epa.gov/gmpo/gmnet/oyster04.htm
- **Oysters . . . In the Environment** - http://www.mdsg.umd.edu/Extension/msgsnn/msgsnn02_2/oysters_envi.html
- **Oysters . . . In the Classroom** - http://www.mdsg.umd.edu/Extension/msgsnn/msgsnn02_2/oysters_class.html
- **Oyster Anatomy Laboratory** - http://www.mdsg.umd.edu/oysters/anatlab/lab_i.htm
- **Oysters - Information and Recipes** - http://homecooking.about.com/library/weekly/aa021201a.htm
- **Galveston Bay Oyster Water Project** (GIS/Water Quality) - http://civilu.ce.utexas.edu/stu/zounrj/background.htm
- **American Oyster** - http://www.chesapeakebay.net/info/american_oyster.cfm
- **The Paynter Labs** - (University of MD) - http://www.life.umd.edu/biology/paynterlab/
- **Various Shellfish-Associated Toxins** (FDA/CFSAN - Bad Bug Book) - http://www.cfsan.fda.gov/~mow/chap37.html

These are only a sample of information sources available on the internet related to oysters.

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Online Resources (Continued)

- **Links for Educators** - http://floridaconservation.org/educator/links.html
- **The National Shellfish Sanitation Program** (FDA) - http://vm.cfsan.fda.gov/~ear/nsspprot.html
- **Shellfish Sanitation Laboratory** (USM/CMS/GCRL) - http://www.coms.usm.edu/GCRL/outreach/sfsanlab.htm
- **Vibrio parahaemolyticus (CDC)** - http://www.cdc.gov/ncidod/dbmd/diseaseinfo/vibrioparahaemolyticus_g.htm
- **Vibrio vulnificus** (CDC) - http://www.cdc.gov/ncidod/dbmd/diseaseinfo/vibriovulnificus_g.htm
- **The Harmful Algae Page** - http://www.whoi.edu/redtide/
- **Harmful Algae Digital Library** - http://nsgd.gso.uri.edu/bloom.html
- **Gulf State Marine Fisheries Commission** - http://www.gsmfc.org/
- **Louisiana Wildlife and Fisheries Oyster Lease Survey Section** - http://oysterweb.dnr.state.la.us/oyster/
- **Louisiana Molluscan Shellfish Program** - http://oph.dhh.state.la.us/sanitarianservices/molluscanshellfish/index.html
- **Mississippi Department of Marine Resources** - http://www.dmr.state.ms.us/
- **Alabama Marine Resources Division** - http://www.dcnr.state.al.us/mr/index.html
- **Alabama Department of Public Health** - http://www.adph.org/

These are only a sample of information sources available on the internet related to oysters.

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Acknowledgments

- Patrick Banks – Louisiana Department of Wildlife and Fisheries
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- Ruth Posadas - Mississippi Department of Marine Resources
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- University of Maryland Sea Grant Extension Program
- University of Southern Mississippi - College of Marine Sciences - Gulf Coast Research Laboratory

I would also like to thank my wife and co-workers for putting up with me, as well as anyone I inadvertently left out.

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Thank you!

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The Mississippi Oyster Schooner *Mamie Foster*